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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

Vol 44

JANUARY, 1945

No. 1

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JOURNAL

OF THE

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No. 1

PRESIDENT'S ADDRESS BEFORE FIFTY-SIXTH SEMI- ANNUAL MEETING*

HERBERT GRIFFIN**

It has been a great privilege and pleasure to me to serve our Society as its President for the years 1943 and 1944, and I wish to thank the other officers, the Board, and the membership for their full cooperation which has made the period of my administration one of the most successful in the history of the Society. With mingled feelings of relief and regret, I shall pass the reins to my successor, and be happy to give him all the assistance in my power.

When I took office I did so with some fear and trepidation believing, as I did at that time, that owing to the world conflagration we would lose a large number of members and suffer financially from lack of support from our Sustaining membership. I am happy to state that my fears were entirely unfounded and that our general membership has actually increased from 1250 on January 1, 1943, to 1614 at the present time, and that our Sustaining members have increased in number and have supported us well.

Our financial position and ability to serve the motion picture industry are now at an all-time high. The members' equity at January 1, 1943, was \$26,053.45. As of today it is about \$41,000. About \$25,000 of this amount is invested in War and U. S. Treasury Bonds. During this trying war period the ability of the Society has been further tested and found thoroughly capable of functioning admirably and promptly in cooperation with other technical bodies.

About the middle of 1943 representatives of several branches of the armed services requested the Society's assistance and cooperation in the preparation of specifications and standards for 16-mm equipment and processes. This project was accepted by the Board of

* Presented at Dinner-Dance, Oct. 17, 1944, during the Technical Conference in New York.

** President, Society of Motion Picture Engineers.

Governors at its meeting on October 17, 1943, and has since been carried out almost to completion under the capable direction of your Engineering Vice-President, and next President, Don Hyndman. In this we have had the cooperation of the personnel of the American Standards Association, the War Production Board, the officers appointed by several branches of the armed services, and the members of our Standards Committee, all under the official title "War Standards Committee on Photography and Cinematography-Z52." Many sets of specifications have been prepared and approved as American War Standards which may become industrial standards in the post-war era. The thanks of the Society and mine personally go to Mr. Hyndman and all his associates on the several committees for the diligence and efficiency with which they carried out this splendid assignment.

At the Spring 1942 Convention there were presented, in the form of a symposium, many technical and tutorial papers dealing with motion picture production. These papers were so well written by well-known authorities—members of our Society—that the Board of Governors at its 1943 midsummer meeting voted to have these manuscripts published in book form. Under the title "The Technique of Motion Picture Production," it was issued in 1944 and it is well worth the purchase price of \$2.80 to members, or \$3.50 to nonmembers. Members who have not purchased a copy are advised to do so without delay as, in addition to its great technical value it will be found most interesting reading.

Television is making great strides and the results of the research and development now being carried on by all television organizations will be manifest after the war. It is certain that motion pictures will be a definite factor in television and the Society's interest is obvious. Through our membership we are participating in, and keeping in touch with, all developments. In addition, the Society at its July, 1944 meeting authorized a voting membership in the Radio Technical Planning Board. This is the organization through which all suggestions for the regulation and assignment of television channels are made to the Federal Communications Commission. The Society's Representative is Paul J. Larsen who will, on behalf of the Society of Motion Picture Engineers, present to the Federal Communications Commission the industry's position and requests for frequency band allocations for immediate post-war initiation of commercial television broadcasting.

Soon after I was elected to office it was necessary for me to transfer to Burbank, Calif., and as a result the President, Executive Vice-President, and Past-President of the Society were all located in Hollywood. To overcome any possible handicap in the handling of the Society's operations, I appointed with the Board's approval an Executive Committee with one of our Past-Presidents and able Secretary, E. Allan Williford, as Chairman. This Committee has handled with dispatch all matters needing executive attention between Board meetings, all of which I fortunately have been able to attend. I want to thank Allan Williford for his splendid cooperation as Chairman of the Executive Committee.

In order to avoid in the future such local concentration of top executive Society personnel, the Board at its July, 1944 meeting ruled that with the approval of the membership a change would be made in By-Law VI, Section 3(a) providing that should the President or Executive Vice-President remove his residence from the Atlantic Coast or the Pacific Coast, as the case may be, where he resided at the time of his election, the office of Executive Vice-President shall immediately become vacant and a new Executive Vice-President be elected by the Board of Governors for the unexpired portion of the term, the new Executive Vice-President to be a resident of that part of the United States from which the President or Executive Vice-President had just moved.

The amendment has been presented to, and approved by, a business meeting of the Society during this Conference. Its approval eliminates the possibility of recurrence of this unsatisfactory situation which has happened several times during the recent history of our Society.

I want to take this opportunity to thank our Convention Vice-President, W. C. Kunzmann, for his fine cooperation in connection with our recent most successful Conferences. I do not know what the Society would do without him. He really has a big job on his hands at our Conferences; stand up and take a bow, Bill.

FELLOW MEMBERSHIP AWARDS

Now, I come to a particularly pleasant part of my duties, that of presenting the Society's annual awards to worthy recipients. It is a policy of the Society through its Fellow Membership Award Committee to select yearly from the Active membership of the Society a number of individuals who, because of their conscientious activities

on behalf of the Society—either as committee members or otherwise—should be rewarded by elevation to the grade of Fellow. This grade is an honorary grade solely under the control of the Board of Governors and may not be applied for.

I am happy to announce that through selection by the Fellow Membership Award Committee and unanimous approval of the Board of Governors, the following members have been elevated to the grade of Fellow in our Society:

Earl J. Arnold, Eastman Kodak Company

F. T. Bowditch, National Carbon Company

Peter C. Goldmark, Columbia Broadcasting System

Barton Kreuzer, RCA Victor Division of Radio Corporation of America

Wallace W. Lozier, National Carbon Company

C. J. Staud, Eastman Kodak Company

James R. Wilkinson, Paramount Pictures, Hollywood.

Will these gentlemen kindly step forward to the speakers' table and receive their Fellow Membership Certificates?

[The newly elected Fellow members who were present stepped forward, and with appropriate words of appreciation of their efforts, President Griffin presented the Certificates.]

JOURNAL AWARD

The Journal Award is made each year to the author or authors of the most outstanding paper originally published in the JOURNAL of the Society during the preceding calendar year. The selection is made by the Journal Award Committee, approved by the Board of Governors and, as has happened this time, other papers may be cited for honorable mention.

The paper to win the 1944 Journal Award was published in the July, 1943 issue of the JOURNAL and is entitled "Removal of Hypo and Silver Salts from Photographic Materials as Affected by the Composition of the Processing Solutions." It was presented during the 1942 fall meeting of the Society. The authors are three in number: one of our past-presidents, J. I. Crabtree, and G. T. Eaton and L. E. Muehler, all of the Eastman Kodak Company, Rochester. The citation on behalf of these 3 gentlemen will be presented by one of their co-workers, Glenn E. Matthews.

CITATION ON THE WORK OF JOHN I. CRABTREE, GEORGE
T. EATON, AND LOWELL E. MUEHLER*

GLENN E. MATTHEWS**

The Journal Award is given annually for the most outstanding paper originally published in the JOURNAL of this Society during the preceding calendar year. It was established in 1933. It is my privilege to announce tonight on behalf of the Journal Award Committee that the Journal Award for 1944 has been made to John I. Crabtree, George T. Eaton, and Lowell E. Muehler for their paper entitled "The Removal of Hypo and Silver Salts from Photographic Materials as Affected by the Composition of the Processing Solutions," published in the July, 1943, issue.

The senior author of this paper, Mr. Crabtree, was born at Clayton-le-Moors, Lancashire, England. He received his basic scientific training at Victoria University, Manchester, England, where he was granted a Bachelor of Science degree with honors in Chemistry in 1912, and a Master of Science degree in 1913. He also passed the rigid requirements of the British Institute of Chemistry and was made a Fellow of the Institute in 1913.

In August, 1913, he was employed by the Eastman Kodak Company at Rochester, New York, as a research chemist in the Kodak Research Laboratory, under the directorship of Dr. C. E. K. Mees. He founded the photographic chemistry department in 1913 and is still the head of this department. From 1916 to 1938, he was also in charge of the motion picture film developing department. As head of these departments, he has conducted and supervised research in many fields of photography, including methods of processing photographic materials, stains and markings, preparation and use of flash powders, tropical development, silver recovery, storage of photographic records, and motion picture processing technique. On this latter subject, to which he has devoted most of his attention, Mr.

* Recipients of 1944 Journal Award of the Society of Motion Picture Engineers; presented Oct. 17, 1944, at the Dinner-Dance during the Technical Conference in New York.

** Research Laboratories, Eastman Kodak Company, Rochester, N. Y.

Crabtree is credited with 54 papers. All told, he has been author and coauthor of about 75 papers and has been granted 20 United States and 3 Canadian patents. His articles have been published in many countries and several have been reprinted as handbooks. He is also the coauthor of a textbook on "Photographic Chemicals and Solutions."

The comprehensive paper on which this Award is based represents one of a series of papers relating to the important problem of insuring maximum permanency of photographic images, which has been investigated for many years under Mr. Crabtree's supervision. Much of this work has been done in collaboration with The National Archives and the Committee on Preservation of Film of this Society. The importance of this work can be appreciated when we consider the millions of films, plates, and paper prints representing valuable records that must be placed in storage each year throughout the world.

Mr. Crabtree has received numerous honors for his work, having been elected to the fellowship of four international photographic and technical societies. With Dr. M. L. Dundon in 1925, he received the Progress Medal of the Société française de Photographie. He has served tirelessly and efficiently on many committees of this Society and has been on the Board of Editors of the JOURNAL of the Society for many years, a portion of this time as Chairman. His wise council was given on the governing Board of the Society for several years, and he was entrusted with the highest office, that of President, in 1929 and 1930.

In private life, Mr. Crabtree describes himself as a farmer, and the fame of his vineyard on Canandaigua Lake near Middlesex, New York, is widely known—especially to his more intimate friends. He became a naturalized citizen in 1925 and takes an active interest in the affairs of the township where he resides.

The second author of the Award paper, George T. Eaton, was born in Edmonton, Alberta, Canada. He attended Brandon College at Brandon, Manitoba, from 1926–1932, and received the Bachelor and Master of Arts degrees from that institution where he specialized in geology, chemistry, and mineralogy. From 1932–1934 he continued his studies at Acadia University, Wolfville, Nova Scotia, where he completed the work for his Bachelor of Science degree. From there he moved westward again to Toronto University to do graduate work in analytical chemistry for 3 years. In 1937 he joined the staff of the Kodak Research Laboratories and worked as a research chemist in the department of photographic chemistry until 1942 when he

moved to the administration staff as assistant to Dr. Walter Clark.

While in the photographic chemistry department, Mr. Eaton devoted the major portion of his time to investigation of 2 problems: (1) the elimination of residual silver and hypo from processed photographic materials, and (2) selenium, gold, and dye coupler toning of photographic papers. On the former subject, he has published 9 technical papers. Two United States patents have been granted to him. Since he joined the administration staff, one of his responsibilities has been the supervision of the production of reticles for instruments used by the Armed Forces.



FIG. 1. Presentation of certificates to recipients of 1944 Journal Award. Left to right, President Herbert Griffin, J. I. Crabtree, G. T. Eaton, and L. E. Muehler.

Outside of his research work, Mr. Eaton's interests are his family, tennis, and music. He is a member of the Photographic Society of America. United States citizenship was granted to him in 1943.

Lowell E. Muehler, the third of this group of authors, was born in Sullivan, Indiana, and received his university education at Rose Polytechnic Institute, Terre Haute, Indiana, where he was granted the Bachelor of Science degree in 1926 and the Chemical Engineer degree in 1927. He has also done graduate work at the University of Rochester in chemistry and optics.

Mr. Muehler joined the Kodak Research Laboratories in June, 1927, to do research in the department of photographic chemistry. Since that date he has carried out theoretical and practical research on many problems, chief among which are the following: the permanency of photographic images, reducers and intensifiers, antihalation backings, tropical processing, antifoggants, analysis of spots and marks, hardeners for gelatin and other colloids, corrosion of materials used for photographic apparatus. The results of some of these investigations have been published in 10 technical articles and 7 United States patents have been granted to him.

For his hobbies, Mr. Muehler enjoys tennis, gardening, and photography. He is a member of the American Chemical Society and of Alpha Chi Sigma, professional chemical fraternity.

It gives me real gratification now to present Mr. Crabtree, Mr. Eaton, and Mr. Muehler to President Griffin, who will present the Journal Award of the Society of Motion Picture Engineers to them.

[The President then presented the Journal Award Certificates, and Mr. Crabtree responded on behalf of himself and associates, as follows:]

As senior member of the family, and speaking for Lowell Muehler and George Eaton, we deeply appreciate this honor.

Receiving this certificate recalls to mind the great amount of time and thought that Glenn Matthews put into getting the certificate designed. After rejecting several unsatisfactory sketches from some of the New York designers, he had the bright idea of establishing a competition among the young art students at the then Rochester Mechanics Institute for the best submitted sketch. Well, here it is. The youthful prize winner is now with one of the outstanding designers here in New York City.

When officiating with Glenn at Kodak Park as judge of the submitted designs, I little dreamt that the chosen one would come home to roost and in such bountiful numbers.

The problem of how to make photographs permanent has been with us since the beginnings of photography. Herschel thought that he had solved the problem when he fixed a photographic image in hypo, but photographs still faded on keeping, as you all know who keep a family album.

We have known for a long time that the main cause of instability of silver images was the presence of traces of residual hypo which were difficult to remove by washing. We now know how to eliminate

the hypo by oxidizing it in a mixture of hydrogen peroxide and ammonia as developed by Lowell Muehler, and we have a more complete knowledge of how to remove hypo quickly by washing because of the painstaking efforts of George Eaton.

An investigation of this nature carried out over a period of many years is, of course, the result of collaboration of many workers, and it would be fitting to inscribe these Certificates with the words, "and to their many co-workers who contributed so generously to this investigation."

[President Griffin continued:]

The paper receiving Honorable Mention was published in the February, 1943 issue of our JOURNAL, entitled "The Effect of Developer Agitation on Density Uniformity and Rate of Development," the authors being C. E. Ives and E. W. Jensen, also of Eastman Kodak Company.

PROGRESS MEDAL AWARD

A gold medal is awarded by the Society to an individual in recognition of any invention, research, or development which in the opinion of the Progress Medal Award Committee shall have resulted in a significant advance in the development of motion picture technology. The nomination was unanimously ratified by the Board of Governors, and I am happy to say that the citation will be read by a man who is, himself, the holder of the 1936 award, and widely known throughout the industry. He is Vice-President in charge of Research and Development of the Eastman Kodak Company—Dr. C. E. K. Mees.

JOHN GEORGE CAPSTAFF*

C. E. K. MEES**

Since the invention of the motion picture, there have been many improvements in the art, but possibly the most radical innovation was the introduction about 20 years ago of films and apparatus especially designed for use by the amateur photographer. These sub-standard films not only made amateur cinematography possible, but they have made a substantial contribution to the professional side of the motion picture art. The success of this introduction was due primarily to our member who is tonight presented for the Progress Award and Medal.

John George Capstaff was born at Gateshead-on-Tyne in England on February 24, 1879. After an education in the Heaton Science and Art School of Rutherford College, Newcastle, he studied at Armstrong College, specializing for the most part in subjects relating to physics and engineering. His family was connected with the shipbuilding industry, for which the Tyne is so famous, and he himself intended to study engineering, but as the shipbuilding industry was suffering from one of its periodical waves of depression, he started work as a young man for a very famous photographer of Newcastle, Mr. Lyddell-Sawyer. There he took an interest in all the work that was being done and seized every opportunity to learn different branches of the photographic art, and so got an excellent grounding in photography, finally specializing in the handcoloring of prints. His interests, however, were largely in mechanical devices, and after he started his own studio, he spent much of his spare time with a group of friends in the consideration of engineering problems, especially those relating to aeronautics, which was then beginning to appear as a fascinating field for the engineer.

* Recipient of 1944 Progress Medal Award of the Society of Motion Picture Engineers; presented Oct. 17, 1944, at the Dinner-Dance during the Technical Conference in New York.

** Vice-President in charge of Research and Development, Eastman Kodak Company, Rochester, N. Y.

While he studied these mechanical problems, Mr. Capstaff was also working on experimental photography and invented several modifications of photographic processes, some of which were later of use to him. One of these was a process of the same type as the now well-known Carbro process, by which prints in carbon tissue could be produced from bromide prints. Another was the production of photographs which were invisible until the paper had been exposed to light, this forming an advertising novelty.



FIG. 2. John G. Capstaff, recipient of 1944 Progress Medal Award.

In 1912, a friend of Mr. Capstaff was talking to Professor F. G. Donnan about some of the inventions he had made, and Professor Donnan asked what Mr. Capstaff was doing. On learning that he was a portrait photographer, he said that he should instead be doing some technical work. He mentioned that Mr. Eastman had asked me to organize a research laboratory for the Eastman Kodak Company and that I was planning to come to America to become director of research for the Eastman Kodak Company. He suggested that Mr. Capstaff should see me and ask whether he could join me.

This was my first meeting with Mr. Capstaff, and as I was anxious to get someone to come with me who could transfer the work we had done on color filters, it was arranged that Mr. Capstaff should come to Wratten and Wainwright and learn our technique, and then come to Rochester in charge of our production of filters and the experimental work related to it.

Mr. Capstaff had not been long in the new research laboratory at Rochester before he began experimental work in several fields of photography. By 1914 he was working on processes of color photography, and a 2-color portrait process, to which we gave the name *Kodachrome*, was worked out by him and exhibited at the World's Fair in San Francisco in 1915. Soon after this, experiments were started to adapt the process to motion picture photography, duplicate negative images being printed from a master positive onto opposite sides of double-coated film by means of an optical printer, these being transformed into dye images by a process related to that on which Mr. Capstaff had worked many years before for the production of carbon prints from bromides.

In 1914, Mr. Capstaff conceived the idea of applying a reversal process to the production of amateur motion pictures. Work on this progressed rapidly, and I have a letter from him dated April 17, 1917, in which he laid down the conditions which he believed necessary for the development of practicable home motion pictures. There had already been work done in this field by others, and much had been done from the standpoint of the design of apparatus, but what was necessary to make the whole thing a success was a simple and inexpensive method of producing the finished pictures, and this was supplied by Mr. Capstaff's invention of a practical reversal process.

The reversal process which was eventually used was based on that proposed by Namias in 1909, in which Namias developed the original negative, bleached the developed image with acid permanganate, and then, exposing the bleached image to white light, redeveloped a positive from the residual silver halide. The difficulty with this process is its great sensitivity to the exact thickness of the emulsion coating. If the emulsion coating is too dense, there is too much silver halide for the second image. If it is too thin, there is too little. Its use requires the adoption of a very thin emulsion having little latitude and necessitates very even coating, any streaks producing serious difficulty. The pictures are dependent upon the original exposure given; there is no means of correcting for errors in exposure. These

difficulties were overcome by Mr. Capstaff by the use of a controlled second exposure, the exposure given after the bleaching of the original image being determined by the density of the silver halide remaining, so that lack of silver halide was compensated for, to some degree, by an increased second exposure, and, similarly, an excess of silver halide resulting from heavy coating or underexposure was compensated for by decreased re-exposure.

The results obtained by this improved reversal process were startlingly better than those which could be made without the control of the second exposure, and it was this which made the process a success. With this as the base of his work, Mr. Capstaff worked on the design of the film itself, the camera loading method, the camera, the projector, and the processing equipment. A great deal of work on the subject was done, of course, by his associates in the Eastman Kodak Company—both the staff of the laboratory and the engineers and chemists of the production departments—but considerably more than half of all the development work involved in the introduction of 16-mm film by the Eastman Kodak Company in 1923 was done by our medalist.

The process was first announced and demonstrated publicly in January, 1923, in lectures at Rochester and at the Franklin Institute in Philadelphia. Pictures were taken at the beginning of the lecture, processed in the building while the lecture was in progress, and shown at the conclusion.

The product was introduced in June, 1923, and in addition to the apparatus made by the Kodak Company itself, competitive equipment—cameras and projectors—were marketed before the close of the year.

Many improvements in the equipment used for exposing, processing, and projecting the film were devised by Mr. Capstaff. For example, the claw pull-down and curved gate used in the Model B Ciné-Kodak represented useful refinements which improved the steadiness and uniformity of the picture. A daylight loading film magazine was designed. Much basic optical work was done on the projector and a friction-type panoramic tripod head was designed which has displaced the gear type in professional as well as amateur tripods.

Several continuous types of 16-mm film developing machines were designed and built, incorporating his inventions. One of the improvements used in these machines was the portable-type rack, permitting

sections of the machine to be removed easily for threading, changes, and inspection.

Extensive investigations were conducted to improve the quality of duplicate prints from 16-mm positives. Mr. Capstaff's suggestions resulted in a steady improvement until it was possible to make duplicates that were almost indistinguishable from the original. Printing equipment used for this work was designed in part by him. Improvements in the film emulsions used for duplicating purposes were also effected at his suggestion.

A new industry is usually the result of the integrated ideas of a large number of individuals, and while this is true in the case of the 16-mm substandard film system, it can be stated fairly that Mr. Capstaff contributed the major portion of the fundamental elements.

During the past 20 years, many competitive cameras and projectors have been marketed. As a general rule, the cameras are driven by spring motors which are wound up between exposures, and cameras for amateur use are made much more compact than the earlier ones. Projectors for 16-mm sound films were introduced in 1932 and cameras in 1935.

In 1932, the "Ciné-8" film and apparatus were introduced, the pictures being one-quarter of the size of the 16-mm picture.

During recent years, there has been a great increase in the use of 16-mm film for educational and industrial purposes. The most striking example of this development is the wide use of 16-mm sound films for training members of the Armed Forces in the present war. Extensive use has also been made of 16-mm sound films for instructing industrial workers. Libraries of films have been established in many parts of the world, where films are loaned for entertainment and instructional purposes. In the field of scientific investigation, 16-mm films are being used to an increasing extent.

Between 1908 and 1925, a 3-color additive process of color photography on 35-mm film was worked out in principle by R. Berthon and A. Keller-Dorian of France. In 1925 this process was demonstrated to the Eastman Kodak Company, and it appeared so promising that they arranged to purchase the rights for its development, particularly as an amateur process of color cinematography. In that year, Mr. Capstaff began work on the adaptation of this process for use with existing 16-mm cameras and projectors. This process, in which a lenticulated film is used, the lenses forming images of filters fitted in the lens, was introduced commercially in 1928.

and was used successfully for several years by amateur motion picture enthusiasts.

Research work on a 35-mm process of the same type was carried on under Mr. Capstaff's direction for several years. A number of improvements in the process resulted in pictures of high quality, a demonstration of which was given before the Society of Motion Picture Engineers in 1936.

While working on his 2-color process, Mr. Capstaff found that the addition of a yellow dye to each emulsion of the double-coated film used in making the duplicate negatives represented a useful method of controlling the depth of the exposure and therefore preventing penetration of the light through the film. The addition of the dye also had the effect of increasing the resolving power of the emulsion by reducing irradiation or scattering, greatly extending the latitude and lowering the maximum contrast. The dye was water soluble and could be washed out during the developing process. Mr. Capstaff realized that the use of a yellow dye would improve the films employed for the making of duplicate negatives and carried out much experimental work, which resulted in the introduction of special films for this purpose. In consequence, motion picture producers established the present practice of duplicating their original negatives, a notable improvement in motion picture technique.

In 1927, Mr. Capstaff established the formula of a developer especially suitable for the production of fine-grained images on negative film. This formula (*D-76*) met with ready acceptance and is used very widely by amateur and professional photographers for all classes of work.

Mr. Capstaff is essentially an experimenter and loves to carry out his work with his own hands, but no account of that work would be complete without some mention of the training which he has given through the years to his associates and assistants. Many men in the organization of the Eastman Kodak Company are proud to acknowledge with gratitude their obligation to him. This feeling is, I am sure, shared by motion picture engineers throughout the industry, many of whom have been helped by his wide knowledge and ready invention.

This statement of his work and recitation of his principal inventions show that motion picture technique owes very much to Mr. Capstaff. In the whole art of photography, he has been a pioneer, and his work has always been distinguished by its accuracy and completeness.

It is with the greatest satisfaction, Sir, that I present to you John George Capstaff for the Progress Medal of the Society.

[The President then presented the Society's gold medal to Mr. Capstaff, who acknowledged the honor bestowed upon him with the following words:]

Mr. President, Dr. Mees, Fellow Members, and Friends:

I have no long prepared speech to give, but I should like to say a few words in accepting the extraordinary honor being conferred on me tonight by the Society.

When a small boy at school, I learned a story which made a lasting impression upon me. It was the one about the youngster who was invited by his uncle to attend a Christmas party where, so he was told, he could partake of a cake made by his aunt with the help of over a thousand persons. The boy was greatly disappointed when he found that the cake was just the regular family size and not, as he had expected, at least as large as a house.

His uncle explained that while his aunt had baked this very fine cake, she could not have done so without the help of a very large number of other persons: for example, the farmers who tilled the earth, sowed the seeds, reaped the wheat; the millers who ground the flour; the trucksters who carried the flour from the millers to the storekeeper who had sold the flour to his aunt. And many other people supplied items that went into the making of this cake: the persons who tended the raisins grown abroad, gathered them, dried them, and shipped them to our ports; and so he went on to show that many more than a thousand persons were concerned in the baking of that cake.

As Dr. Mees has indicated, I, from time to time, had the idea that I should like to bake cakes, different perhaps in some degree from cakes made hitherto, but, like the aunt in the story, I could have made very little headway had it not been for the help of a great many persons, both within my department and outside of it. For example, Dr. Mees has spoken tonight of the men who left the photographic department to assume other responsible positions in the company. It surely seems clear that these men who are now doing such splendid work elsewhere contributed much while members of my department. I am happy and proud to acknowledge the great help given me by them and by those still with me.

The working out of ideas, advice, and practical help were contributed also by many in other departments of the research laboratories;

I am thinking of members of the physics and chemistry departments. Of those outside the research laboratories, I remember the immense help received from the emulsion department, the engineering and mechanical staff, and others in Kodak Park. Going farther afield, I am thinking of Hawk-Eye Works opticians, the instrument makers, and others who gave generously of their knowledge and skill. I count myself as singularly fortunate in the friendly manner in which these experts have always collaborated with me in the development of ideas.

I wish, then, if I may, to accept this high Award on behalf of all past and present members of the "Cappy" gang and their friends. Thank you.

RERECORDING 35-MM ENTERTAINMENT FILMS FOR 16-MM ARMED FORCES RELEASE*

P. E. BRIGANDI**

Summary.—*In preparing 35-mm entertainment films for 16-mm release to the Armed Forces, a rerecorded 16-mm negative is used for contact release printing. Restricted frequency and volume ranges are applied in the rerecording to meet the limitations of reproduction in the field.*

Prior to the war, the few 16-mm sound prints RKO needed were made by optical reduction from the original release negative. This provided a convenient and inexpensive way to make single prints, and the quality was considered adequate for projection to small groups. When RKO began releasing the majority of their 35-mm entertainment films on 16-mm to the Armed Forces, optical printing could not suffice as it was too slow to provide the large number of prints required. While 16-mm contact printing was more rapid it necessitated making a 16-mm negative, the first of which was optically reduced from a fine-grain 35-mm print.

When prints of these negatives were projected on an average 16-mm reproducer the sound was not uniformly intelligible or pleasant to hear. The 3 main causes for this deficiency were (1) the overloading and resonant peaks of the projector speaker when reproducing low frequencies, (2) the resultant surface noise and the noise of the projector running in the room prevented the low passages of dialogue from being heard, and (3) the relative lack of resolution in the film and variations in printer contact were causing the extreme high frequencies present on the track to intermodulate.

The only solution was to restrict the frequency and volume ranges by rerecording. The simplest procedure was to rerecord from a 35-mm release print directly to a 16-mm negative. The alternative of rerecording a second time to 35-mm and making a 16-mm negative by optical reduction was discarded as it was wasteful of 35-mm raw stock and

* Presented Apr. 19, 1944, at the Technical Conference in New York.

** RKO Radio Pictures, Inc., Hollywood.

increased the cost. Using the original units as prepared for rerecording the 35-mm release negative was not necessary as the distortion introduced in rerecording from this rerecorded 35-mm release track was not sufficient to reduce intelligibility.

RCA Recording Studios, having a high-quality 16-mm recorder and considerable experience in recording this type of negative particularly for "Soundie" 16-mm releases, were glad to cooperate in meeting the emergency. However, the "Soundie" recordings involved only orchestral and small vocal groups and were designed to be reproduced on a standardized projector unit. On the other hand, the 35-mm entertainment films consisted of wide-range dialogue, music and effects. Besides, the 16-mm versions were to be reproduced on various types of projection equipment under possible adverse conditions. In view of this and the objections mentioned earlier, it was decided to attenuate the low frequencies, increase the mid-range frequencies, sharply attenuate the high frequencies, while drastically limiting the volume range.

To produce a 16-mm sound negative having these characteristics a rerecording channel was set up. This is similar to a standard 35-mm channel except for 4 special units of equipment and changes in one existing unit. The special units consisted of a 16-mm pre-equalizer, a 4500-cycle low-pass filter, a 16-mm monitor decompensator, and an RCA 16-mm recorder equipped with a standard bilateral variable-area modulator and shutter-type noise reduction system.

The 16-mm pre-equalizer is used for the purpose of overcoming the high-frequency loss inherent in 16-mm sound track. This does not equalize for the total losses at the high frequencies in 16-mm recordings, but is a compromise to simulate some apparent high frequencies.

The 4500-cycle low-pass filter sharply attenuates the high-frequency response above 4500 cps. This attenuation is necessary for satisfactory 16-mm release prints and limits the amount of intermodulation produced in the reproducing system and laboratory processing.

The 16-mm monitor decompensator is inserted before the regular 2-way monitor-system and the neon volume indicator. The purpose of this attenuation is to give a monitor characteristic similar to that which may be expected in the field.

The electronic compressor used in the 35-mm channel is adjusted to operate as an electronic limiter. This limiting action is variable but usually compresses 17 db of modulation range on the 35-mm

track into 3 db of modulation on the 16-mm track, expressed as "17 into 3." By increasing or decreasing the attenuation ("ceiling control") following the limiter this compressing action may be started at any desired level ("breakaway point") with respect to 100 per cent modulation on the 16-mm track. For the majority of this work the attenuator is set so the breakaway point is about 5 db below 100 per cent modulation. This automatically raises the low-level dialogue to a higher level while maintaining protection against overload from the louder dialogue and music passages.

Sixteen-millimeter operation of the rerecording channel is similar to 35-mm work, but is simplified by using the release prints as the effects, dialogue, and music are already combined. The average volume range and frequency characteristic of the 35-mm track is observed by projecting one or 2 reels of the picture to be rerecorded. A compression ratio is then determined which keeps the normal dialogue level some 3 db below the loud music level. The very low-level dialogue will then be kept to a level not lower than 5 db below the normal. It is necessary with this amount of compression to change the ceiling control on loud music and effects to prevent "squeezing."

The negative stock used has been EK 5357 exposed with ultraviolet light. Recently, tests on the new EK 5372 exposed with incandescent light have shown excellent results. Either stock is developed to a high contrast (near gamma infinity) and exposed with sufficient light to give a track density of about 2.00. Contact prints on EK 5302 are then developed to normal picture contrast with a track print density of about 1.50. Low negative and positive fog coupled with good printer contact and the elimination of extreme high frequencies during rerecording provide rather broad processing tolerances.

The method outlined in this paper must be considered a war emergency expedient, as it is realized that the dramatic values of certain pictures may suffer with this treatment and that the total distortion introduced is higher than desired. However, the main purpose is to provide our Armed Forces with 16-mm releases, having high intelligibility under all conditions of projection.

Acknowledgment is gratefully given to W. M. Dalglish of RCA Victor Division for his pioneering in this field and for assisting in the preparation of this paper, and to Sid Kramer of RKO Radio Pictures, for his cooperation in the program.

DISCUSSION

DR. HONAN: Supplementing Mr. Brigandi's excellent paper, I would like to have an opportunity to present to the meeting a rerecording of the Academy test reel, to show further what is proposed in the way of transferring 35-mm sound track and picture to 16-mm for the Armed Forces release. The film which I am about to run is the standard Academy test reel with which most of you may be familiar. It is the film which we use in Hollywood for checking sound quality, as well as other features of motion picture work. The Academy film is made up of excerpts provided by the various studios. The film itself is not rerecorded, each section from each studio being printed from the negative which that studio has applied. Therefore, the equalization and sound qualities of each section are in accordance with the standard practice of the studio supplying the section.

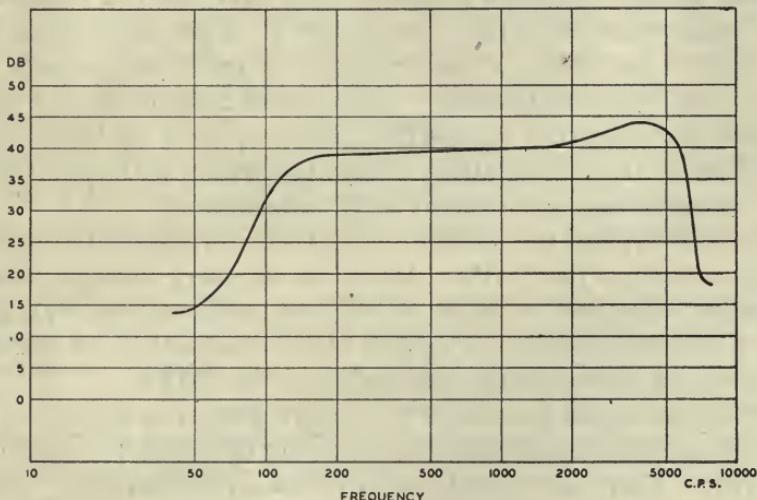


FIG. 1. Dubbing equalization applied to a 35-mm release print used to produce a 35-mm negative for reduction printing to 16-mm.

In the preparation of the film I am going to show you, Metro-Goldwyn-Mayer, in cooperation with the Academy, made a special 35-mm dubbing. In this dubbing the channel equalization is also shown by the curve in Fig. 1. This specially dubbed print was then optically reduced to 16-mm by the Consolidated Film Laboratory. The optical reduction was done with a white light printer.

I wish to point out that this is the first attempt in this line of work, and the Academy, together with the studios, is actively pursuing the work so that the final answer as to the techniques employed is not yet available.

ORGANIZATION OF COMMITTEES ON ENGINEERING OF THE SMPE*

D. E. HYNDMAN**

There have been numerous occasions in the past few years when chairmen and members of committees on engineering of the Society of Motion Picture Engineers explained that they did not understand their responsibilities, duties, and authority. Each emphasized that this lack of knowledge about organization procedure literally prevented him from contributing to the work of committees and to the progress and prestige of the SMPE. The purpose of the following explanation of the organization, policy, procedure, and operation of committees on engineering is to clarify this situation.

There always has been, there is, and there always will be a job for everyone to do in the SMPE. All that is necessary is a sincere interest and a willingness to work actively on problems confronting the motion picture industry. If a job is to be accomplished, all must understand and appreciate the organization of the SMPE.

A business organization may be roughly defined as a group of one or more individuals associated in ownership or conduct of a business for profit. There are many types of business organizations—general partnerships, limited partnerships, joint stock companies, syndicates, joint ventures, pools, corporations (producing, distributing, trading, and marketing), trusts, nonprofit organizations, human organizations (family, welfare, noncommercial), etc. Likewise, there are many types of profit—monetary (income from investments and salaries), knowledge and experience given and received, association with recognized authorities in their fields of endeavor, accomplishment in guiding industry, etc.

The SMPE is an engineering organization of a group of individuals associated in a general partnership to conduct a business paying no salaries to officers or members, but operating on a nonmonetary profit principle to recommend procedures, to guide to some extent

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** Engineering Vice-President, Society of Motion Picture Engineers.

research and development, to encourage improvement, and to lead standardization within the motion picture industry. Organization reacts upon operation and the success of our enterprise. This is largely determined by the character and strength to do business. The character of our organization is of great importance to all officers and the Board of Governors responsible for organizing, guiding, and directing the business affairs. The committees on engineering have much to do with determining this character and strength of the SMPE, because theirs is the engineering job in its truest scientific and business sense.

The Engineering Vice-President of the Society has the responsibility, duty, and authority to make decisions on all engineering matters and problems representing transactions within, through, or by the Society. Naturally, it is understood that all such matters will be discussed with the President, or the Executive Vice-President, or the Board of Governors, or, if of sufficient importance, with the entire organization. He appoints, organizes, and coordinates the membership and work of all committees on engineering. All these committees have fundamentally the same authority, responsibility, and duty.

Each chairman of each committee has authority of action and decision on all matters representing transactions within, through, or by his committee. He can select the membership, organize and coordinate the projects in the specific field assigned to the committee, approve reports in conjunction with committee members, and transact the general business of the committee.

Each chairman is responsible to the appointing officer for all transactions conducted by his committee, and for surveying the field to which his committee specifically applies, with an endeavor to search out projects that warrant consideration, and to be constantly alert for possibilities of standardization of any specific and tried procedure, method, construction, or device that will add accomplishment to the motion picture industry. For committees on engineering, this directly implies that the chairmen will regularly consult or correspond with the Engineering Vice-President on these subjects so that adequate reports of the work and progress can be prepared and published for the benefit of the industry.

Each chairman and member should execute the general business and work of his committee aggressively but tactfully. It is the chairman's duty to facilitate and expedite work efficiently by appointing subcommittees to which specific tasks may be assigned whenever

such a method is deemed desirable. Subcommittees generally function best with not more than 5 members because large membership requires too many adjustments. The chairman should continually check the progress of the work of such subcommittees to assist in expediting the work. All inter- and intracommittee general correspondence should be handled promptly to encourage interest and confidence in the sincerity of the effort. Whenever a report is prepared, it must have a majority affirmative vote consisting of three-quarters of the committee membership to constitute approval for submission to the appointing officer (Engineering Vice-President), or for submission for publication in the JOURNAL of the SMPE. While engineers or authorities on motion pictures may serve on committees, only members of the SMPE may vote on any project.

All discussions and transactions either inter- or intracommittee are to be treated as the confidential property of the SMPE and the committee. No publicity about the work of any committee may be released by the chairman or any member of it without the approval of the President and the appointing officer.

There are 13 regular major committees on engineering:

Cinematography

Color

Exchange Practice

Laboratory Practice

Nontheatrical Equipment

Preservation of Film

Process Photography

Sound

Standards

Studio Lighting

Television

Test Film Quality

Theater Engineering

(1) Film Projection Practice

(2) Screen Brightness

(3) Television Projection Practice

(4) Theater Engineering, Construction, and Operation

Each of these committees is directly responsible to the Engineering Vice-President (as mentioned earlier), to the Executive Vice-President, the President, the Past-President, the Board of Governors, and finally the members of the Society. It is obvious, therefore, that copies of all correspondence emanating from either the Engineering Vice-President or the chairman of any committee should be sent to the

Executive Vice-President, the President, the Past-President, and the Executive Secretary of the Society. This procedure serves to keep the proper officers informed and also keeps a record of all engineering activity in the office of the Society for reference of future incumbents.

With knowledge of the organization and functioning of these committees, it becomes necessary to have an idea of their scope of activity in the respective fields of the motion picture industry to which each committee is classified and assigned. Prescribed details cannot be given here, but perhaps a broad outline will prove of assistance.

The Committee on Cinematography should make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture cameras, accessory equipment, studio and outdoor set lighting arrangements, camera technique, and the varied uses of motion picture negative films for general photography.

The Committee on Color should make recommendations and prepare specifications for the operation, maintenance, and servicing of color motion picture processes, accessory equipment, studio lighting, selection of studio set colors, color cameras, color motion picture films, and general color photography.

The Committee on Exchange Practice should make recommendations and prepare specifications on the engineering or technical methods and equipment that contribute to efficiency in handling and storage of motion picture prints, as far as can be obtained by proper design, construction, and operation of film handling equipment, air-conditioning systems, and exchange office buildings.

The Committee on Laboratory Practice should make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture printers, processing machines, inspection projectors, splicing machines, film cleaning and treating equipment, rewinding equipment, any type of film handling accessories, methods, and processes which offer increased efficiency and improvement in the photographic quality of the final print.

The Committee on Nontheatrical Equipment should make recommendations and prepare specifications for the operation, maintenance, and servicing of 16-mm motion picture projectors, splicing machines, screen dimensions and placement, loudspeaker output and placement, preview or theater arrangements, and the like, which will improve the reproduced sound and picture quality of 16-mm prints.

The Committee on Preservation of Film should recommend and prepare specifications on methods of treating and storage of motion

picture film for active, archival, and permanent record purposes, so far as can be prepared within both the economic and historical value of the films.

The Committee on Process Photography should make recommendations and prepare specifications on motion picture optical printers, process projectors (background process), matte processes, special process lighting technique, special processing machines, miniature set requirements, special effect devices, and the like, that will lead to improvement in this phase of the production art.

The Committee on Sound should make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture film, sound recorders, rerecorders, and reproducing equipment, methods of recording sound, sound film processing, and the like, to obtain means of standardizing procedures that will result in the production of better uniform quality sound in the theater.

The Committee on Standards should constantly survey all engineering phases of motion picture production, distribution, and exhibition to make recommendations and prepare specifications that may become proposals for SMPE Recommended Practices and/or American Standards. This Committee should carefully follow the work of all other committees on engineering and may request any committee to investigate and prepare a report on the phase of motion picture engineering to which it is assigned.

The Committee on Studio Lighting should make recommendations and prepare specifications for the operation, maintenance, and servicing of all types of studio and outdoor auxiliary lighting equipment, tungsten light and carbon arc sources, lighting effect devices, diffusers, special light screens, *etc.*, to increase the general engineering knowledge of the art.

The Committee on Television should make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture theater television equipment giving full consideration to the engineering phases of television which effect origination, transmission, distribution, and reproduction of television in the theater.

The Committee on Test Film Quality should supervise, inspect, and approve all print quality control of sound and picture test films prepared by any committee on engineering before the prints are released by the SMPE for general practical use.

The Committee on Theater Engineering comprises the membership

of 4 subcommittees under a single general chairman, but each subcommittee has a distinct and separate scope of activity. The Subcommittee on Film Projection Practice should make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture projection equipment, projection rooms, film storage facilities, stage arrangements, screen dimensions and placement, and maintenance of loudspeakers to improve the quality of reproduced sound and the quality of the projected picture in the theater.

The Subcommittee on Screen Brightness should make recommendations, prepare specifications, and test methods for determining and standardizing the brightness of the motion picture screen image at various parts of the screen, and for specific means or devices in the projection room adapted to the control or improvement of screen brightness.

The Subcommittee on Television Projection Practice should make recommendations and prepare specifications for the construction, installation, operation, maintenance, and servicing of equipment for projecting television pictures in the motion picture theater, as well as projection room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in high-quality theater television presentation.

The Subcommittee on Theater Engineering, Construction, and Operation should make recommendations and prepare specifications on engineering methods and equipment of motion picture theaters in relation to their contribution to the physical comfort and safety of patrons, so far as can be enhanced by correct theater design, construction, and operation of equipment.

All of these committees have in the past year had many of their members doing work on various subcommittees of the American Standards Association War Committee on Photography and Cinematography-Z52. Twenty-five standards have been completed representing projects urgently needed by the Armed Forces of the United States, and more than 25 additional standards in the fields of both still and motion picture photography are on the way.

16-MM MOTION PICTURES

* Service Model Projection Equipment, Z52.1-1944 (JAN-P-49)

* Release Prints, Z52.3-1944 (JAN-P-55)

Sound Records and Scanning Area for Prints, Z52.16-1944

Leaders, Cues, and Trailers for Reduction Prints, Z52.19-1944
Positive and Negative Splices for Processed Films, Z52.20-1944

Test Methods

Determining Freedom from Projector Travel Ghost, Z52.4-1944
Determining Resolving Power of Projector Lenses, Z52.5-1944
Determining Projector Picture Unsteadiness, Z52.6-1944
Determining Uniformity of Projector Scanning Beam Illumination, Z52.7-1944

Test Films

Multi-Frequency Test Film, Z52.8-1944
3000-Cycle Flutter Test Film, Z52.9-1944
Buzz-Track Test Film, Z52.10-1944
Sound-Focusing Test Films, Z52.11-1944
400-Cycle Signal Level Test Film, Z52.17-1944

Printer Aperture Dimensions

Positive Aperture for Reduction Printing, Z52.24-1944
Negative Aperture for Reduction Printing, Z52.25-1944
Positive Aperture for Contact Printing, Z52.26-1944
Aperture for Reversal Prints, Z52.27-1944

35-MM MOTION PICTURES

Picture Projection Aperture, Z52.27-1944
Camera, Photographing Aperture, Z52.35-1944

EXPOSURE METERS

* Service Model Exposure Meter, Z52.12-1944 (JAN-M-58)
Acceptance of Reflected Light Meters, Z52.21-1944
Calibration of Reflected Light Meters, Z52.21-1944
Abuse Testing Mechanism, Z52.30-1944

* JAN Specifications and American War Standards listed together are technically identical.

The procedure necessary for the formulation of these American War Standards for motion picture equipment and processes, and the relationship to this project of members of the committees on engineering and the SMPE, were described in two earlier papers, "War Standards for Motion Picture Equipment and Processes," and "Report of the Engineering Vice-President on Standardization," which appeared in the April, 1944, issue of the JOURNAL of the Society, pages 211-229, and in the July, 1944, issue, pages 1-4, respectively. The planning, initiation, and prosecution of the major project of the preparation, study, and issuance of the various specifications have

afforded the Society of Motion Picture Engineers an opportunity to collaborate with the Armed Forces, the War Production Board, the American Standards Association, and the motion picture industry along lines which, it is believed, have been of constructive assistance to the war effort.

Several of the committees have definite projects in work on which reports will be presented to the SMPE within the coming year. The Committee on Laboratory Practice expects to prepare a report to present to the next convention on "Current Motion Picture Laboratory Practice" which will describe in detail both 35-mm and 16-mm procedures for handling motion picture film. This committee also has in progress a report on "The Design, Construction, and Operation of a Modern Motion Picture Laboratory." In addition, work is being done toward the standardization of the notching technique used both in the timing and printing of motion picture film.

The Committee on Nontheatrical Equipment is preparing a report containing recommendations and specifications for the use of 16-mm sound-on-film projectors in specified preview rooms for both industrial and educational purposes. This report will contain very definite recommendations which will incorporate much of the work that has been accomplished by the American Standards Association in the preparation of American War Standards.

The Committee on Preservation of Film has in preparation a report on "The Storage of Valuable Motion Picture Film for Permanent Record Purposes" which will give specific recommendations and specifications about the proper procedure to follow. This report will be presented at the next convention of the SMPE.

The Committee on Sound is studying the current recommendations for 35-mm and 16-mm sound track positioning and scanning which will, within the next few months, result in an American Standard.

The Committee on Standards has a number of projects under consideration: Glossary of Terms for the Motion Picture Industry, 35-mm and 16-mm Sound Track Standardization, studies on the 35-mm Dimensional Specifications for Intermittent Sprockets which it is believed will lengthen the life of 35-mm prints, Specifications for the Cutting and Perforation of 16-mm Raw Stock Motion Picture Film, etc. These projects will be discussed in future reports from this Committee, and it is believed some of them will be completed before the next convention.

The Committee on Television has, through the SMPE, designated Paul J. Larsen as its Representative and E. I. Sponable as Alternate at the hearings of the Federal Communications Commission beginning on October 28, 1944, specifying that the Representative shall present the frequency allocation needs of theater television and its allied services in the foreseeable future to the Commission at that time. The full details of the resolutions on frequency allocation for theater television will be published in report form as soon as the material has been presented to the Federal Communications Commission. This work has entailed a great deal of effort and organization, and it would appear to be one of the most important steps ever undertaken by the SMPE. This Committee has additional work in progress which will undoubtedly be prepared and ready for presentation at the next convention.

The Subcommittee on Film Projection Practice of the Committee on Theater Engineering is now preparing recommendations and specifications for the design and construction of a 35-mm sound-on-film projector which will offer considerable improvement over present equipment.

The Subcommittee on Screen Brightness will again resume active work upon the problem of providing adequate methods of measuring screen brightness by means of devices in the projection room which will be suited to a better control of projection quality in the theater.

The Subcommittee on Television Projection Practice is formulating an active program to coordinate with the work of the Committee on Television.

The Subcommittee on Theater Engineering, Construction, and Operation is in the process of organizing further details about the work of this Committee which will undoubtedly be presented at the next convention.

These projects are being completed as rapidly as possible because of the very cooperative effort of the members of the SMPE, and it is believed that as a result of this intensive work many new procedures will appear which will eventually result in the production of a number of American Standards. Only by a unified effort of each and every member of each and every committee on engineering can we, as a Society, expect to progress and accomplish the tasks that are self-evident to us.

APPLICATION OF SOUND RECORDING TECHNIQUES TO AIRPLANE VIBRATION ANALYSIS*

J. G. FRAYNE AND J. C. DAVIDSON**

Summary.—This paper describes methods which have been developed for analysis of the various vibration components present in airplane structures. The complex wave forms are recorded on standard motion picture sound negatives during flight. These films later, after proper development, are analyzed electrically, making possible a complete analysis on the ground and thereby reducing materially the time devoted to flight test, and also simplifying the process of analysis of complex wave forms.

In the fall of 1940 a conference of aircraft engineers and government representatives was held to consider ways and means for obtaining adequate apparatus for use in aircraft vibration testing. At that time, one method of vibration analysis consisted of flying all of the analyzing equipment, and the various vibration rates were determined one by one during the flight test. There were several objections to this method of operation. In the first place, it could be used only in planes sufficiently large to carry the test equipment and test personnel. Also, the conditions being studied frequently changed, or could not be maintained sufficiently long for the purposes of the test. Last but not least, it consumed many hours of very expensive flight time.

Another method of test widely in use provided means for recording approximately 12 galvanometer traces on a large roll of sensitized paper which was subsequently developed on the ground. After this, it required many man-hours of work, over a period of months in some cases, before a Fourier analysis of the fundamental frequencies and a few of their higher orders (or harmonics) could be made available for the aircraft designer's information.

It was apparent that the ideal test equipment was one that would make a record of the output of possibly 12 vibration pickups and at

* Presented Oct. 17, 1944, at the Technical Conference in New York.

** Electrical Research Products Division of Western Electric Company, Hollywood.

any desired later time reproduce them in a manner that would permit electrical analysis of the component frequencies contained in the recorded complex vibration signal. After due consideration, we undertook to accept the output of 13 amplifier channels, record the information onto 13 sound tracks in line on film, and deliver the reproduced sound track outputs at a sufficient level to a suitable electrical analyzer.

A study of the problem disclosed that the aircraft industry was concerned with three different types of vibration problems, each in general covering a different range of frequencies, but otherwise having about the same equipment requirements. These were:

- (1) Tests of airplane structures which were in general concerned with low-frequency vibrations of the aircraft structure arising from aerodynamic causes.
- (2) Propeller tests which were concerned with forced vibrations in the lower audio range.
- (3) Aircraft engine tests, the problems of which closely paralleled both of the above classes, that is, the higher frequency forced vibrations in the engine itself and the low frequencies in connection with engine mounts.

Considering the divergence of application of the desired test equipment, a remarkably close agreement was obtained regarding the specific requirements to be met. The greatest divergence in requirements was with respect to frequency response. It was found that the test equipment should cover a frequency range from 5 to 3000 cps. It also developed that the speed at which the record must be run ranged from 3 to 12 in. per sec.

The specifications that were finally formulated are too lengthy for enumeration and covered many pages. It is interesting, however, to note a few of the requirements. The total harmonic distortion between the input to the light valve and reproduced signal should not exceed 4 per cent. A total frequency range from 5 to 3000 cps should be flat within 5 per cent. Also, the level difference or sensitivity among any of the 13 channels should not deviate from a mean by more than 5 per cent.

The scope of this paper will confine itself to an analysis of the problem and a review of the considerations that led to the decisions as to what type of equipment would be used. The actual embodiment of these considerations into the vibration recorder, reproducer, and amplifier channels is described in two other related papers.^{1, 2}

At first glance everything seemed quite straightforward. The output of 13 amplifier channels would be recorded as 13 separate sound tracks across 35-mm film. The film would subsequently be developed and reproduced in a machine that was capable of simultaneously scanning 13 sound tracks across the film in line, and at the same time the 13 modulated light beams would be led to 13 photocells by an appropriate optical system. The output of the 13 photocells would be suitably amplified with 13 amplifiers, and the 13 signals would be passed through a multichannel analyzer. With a 4-channel analyzer any four of the tracks could be simultaneously explored for a fundamental and any higher order of vibration disturbance. The output of the analyzers could be read on a meter, viewed on an oscilloscope, or recorded as a calibrated graph. It is obvious that the measuring equipment should not introduce any significant frequency or amplitude modulation, or phase distortion of its own, else the resulting analysis would give false information.

The most difficult distortion to eliminate in this type of equipment is the introduction of frequency modulation of the recorded signal by speed variations or flutter in the recording and reproducing mechanisms. The effect of flutter on the quality of sound records is well known, but its effect on quantitative measurements of single frequencies as transmitted through narrow-band pass filters is not so well understood.

A very comprehensive analysis of the effect of flutter on sound recordings has been made by Shea, MacNair, and Subrizi.³ They found that the presence of flutter produces what is in effect a frequency modulation of the signal. In accordance with the well-known characteristics of FM radio transmission,⁴ there results in addition to the fundamental or carrier frequency, a series of side bands, the number and amplitudes of which depend on what is known as the modulation index. The latter is defined as the ratio of the frequency deviation from the normal produced by the presence of flutter to the cyclic frequency, or what is generally known as the flutter frequency rate. The amplitudes of the carrier or normal frequency and the various side-band frequencies introduced by flutter are given by the Bessel coefficients $J_0(\alpha)$, $J_1(\alpha)$, $J_2(\alpha)$, etc.

If we assume a 2000-cycle carrier being modulated \pm one per cent by flutter in the recording mechanism, the flutter rate being 20 cycles per sec, the frequency will vary from 1980 to 2020, 20 times a sec. Then $\alpha = \Delta f_0/f_m = 20/20$ or 1.0. From a chart of Bessel's functions

shown in Fig. 1, we then find the following values may be assigned to the carrier and side-band frequencies:

2000	$J_0 = 0.76$
2020	$J_1 = 0.43$
2040	$J_2 = 0.11$
2060	$J_3 = 0.02$

Similar values exist for the lower side-band frequencies.

It would appear, therefore, that in a recorder having a one per cent flutter amplitude at a 20-cycle rate, the amplitude of the carrier or normal tone will be reduced by 24 per cent, while spurious side-band frequencies of considerable amplitude will be introduced which might be erroneously attributed to the mechanism under test. As the carrier frequency is reduced, the effect of flutter is correspondingly lowered, while reducing flutter rate results in an increase in the number and amplitude of the spurious components.

The design of modern sound recording equipment usually results in flutter values that do not exceed ± 0.1 per cent at any particular rate, while the lowest flutter rate is usually of the order of one cycle per second. If we arbitrarily set a value for the modulation index of 0.5 as the maximum that can be tolerated, we thus obtain a maximum frequency deviation or $f_0 = 0.5$. Since this is 0.1 per cent of 500 cycles, the latter is the top frequency which can be analyzed and meet the specified limit on α with the flutter amplitude and rate listed above. It follows that much greater flutter amplitudes can be permitted at higher flutter frequencies; hence the emphasis that must be placed on reducing the amplitude of low-frequency flutter components to the minimum.

The frequency band width of the analyzer plays an important role in the analysis of vibrations. It must be narrow enough to permit resolution of the lower vibration components and yet wide enough to permit readings of the higher frequencies without introducing variations attributable to drift or low-frequency flutter disturbances. For vibration frequencies below 10 cycles per sec, a band width of possibly one cycle per second would be ideal, while above this value a band width of 4 cycles has proved to be quite satisfactory. A filter with a band width proportional to the frequency being analyzed would appear to be ideal, but since such filters usually have a sharply peaked response, their use in many ways is not as ideal as the flat-top, constant band width type.

It is obvious that a filter with a 4-cycle band width will discard the side bands introduced by flutter, provided the flutter rate exceeds the 4-cycle per sec value. At the same time, it will permit the evaluation of these side-band components which the observer would have to distinguish from true vibration components present in the structure under test. For flutter frequencies below the band width frequency, it is apparent that some of the side-band frequencies will be included

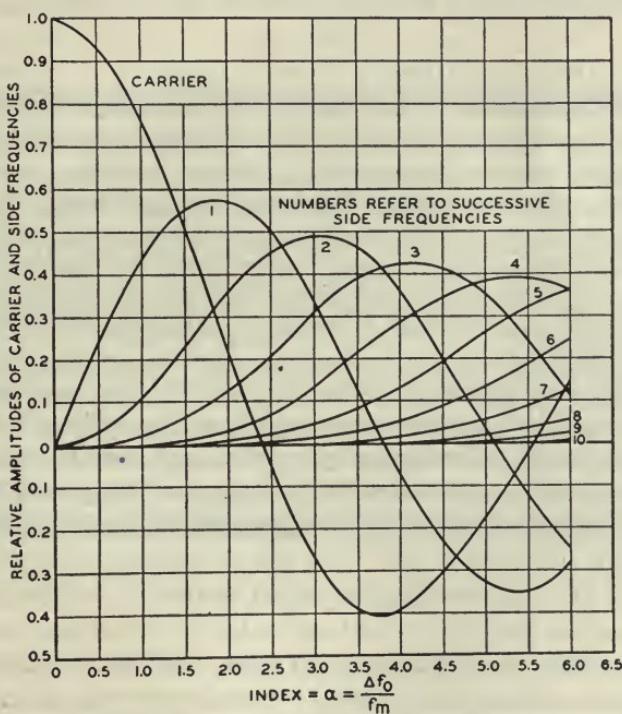


FIG. 1. Chart of Bessel's functions showing relation between carrier and side-band frequencies.

with the carrier that is being measured. According to FM principles, the resultant vector sum of the carrier and all side bands remains constant and equal to the unmodulated carrier amplitude. Thus, if a sufficient number of side bands are incorporated within the filter band width, and if the response of the analyzer is linear and also shows no phase or frequency discrimination within this band, the resultant output should give the true value of the carrier that would be found if no flutter were present. Obviously this condition can only

exist for extremely low flutter frequency rates in an analyzer with a 4-cycle band width.

Recorder Drive.—The problems of the film propulsion for the recorder were analyzed on the basis of the foregoing. The type of film drive was selected after due consideration of the probable effects of the yawing and pitching of an airplane on the recorder mechanism. It consisted of 2 stages of speed reduction using the series cord belt type of drive. This appeared to eliminate any preceding gear disturbance without introducing any disturbance of its own.

Motor.—After investigating various types of drive motors, it was found that with a d-c motor operating from storage batteries, satisfactory performance might be expected. Sufficient studies were carried on with this motor to indicate that all rates of flutter below 22 cps might be expected to be less than ± 0.1 per cent. At the lowest rate of disturbance to be found in the recorder, this would produce a sufficiently small modulation index to assure the determination of the amplitude of a component frequency up to approximately 750 cycles.

Modulator and Optical System for the Recorder.—A study of the requirements indicated that a single light source and optical system interrupted by 13 vibrating elements in line would be required. This automatically eliminated consideration of variable-density recording, since no obvious way of recording 13 variable-density tracks in line occurred to us. The use of variable-area type tracks also offered the opportunity for visual inspection of the tracks by means of a slide projector or a tool maker's microscope, should the occasion for this type of inspection arise. It was accordingly decided to concentrate on a multiple Einthoven type of modulator, containing 13 tuned ribbons in a single permanent magnet field, the whole assembly to be hermetically sealed for protection against dust. One of the requirements was that light valves be interchangeable without affecting track positions and without requiring a change of focus or the relocation of the exciter lamp. Inasmuch as the equipment was to be used by personnel not skilled in handling sound recording apparatus, it was essential that the light-valve ribbons be capable of maintaining their tuning and spacing to a high degree of accuracy over a period of a year or longer without attention.

The space available on the film for 13 sound tracks permitted a

maximum useful width for each sound track of approximately 32 mils. Fig. 2 is a photograph of actual vibration recordings showing the 13 tracks. Since the ribbons are 6 mils wide, this called for an optical magnification of approximately 5.3. This in turn placed very stringent mechanical requirements on the spacing and locating of the ribbons in the light valve, as a one-mil displacement of a sound track represented less than 0.2 of a mil error in the location of the ribbon in the light valve. A number of valves of this type have subsequently been built. They have proved highly satisfactory and have maintained their alignment and tuning over long periods of time.



FIG. 2. Typical 12-channel vibration recording with control frequency on thirteenth channel.

Film Analysis.—There seemed little likelihood that commercial printers could be counted on to hold flutter within the required limits so that means had to be considered for using the original negative record for playback. An investigation in 1942 of available film emulsions showed that none was satisfactory for direct reproduction from variable-area negatives. While it was possible to secure reproduction that was relatively free of distortion, the optimum film density fell at about 0.6, a point at which considerable amplitude variation exists if the density varies about this point because of changes in lamp exposure or development conditions. Consequently, with the aid of the Eastman Kodak Company, a special emulsion, later coded EK 1371, was developed for this specific type of work. This is an exceedingly fine-grain film

mounted on a nonhalation base. Optimum operating density values lie between 1.0 and 1.2, and in this range only slight amplitude changes result from changes in density from any cause. This film is inherently high contrast, and while it may be developed satisfactorily in an ordinary motion picture bath, best results are obtained in a solution specifically designed for the development of high contrast variable-area negatives.

Reproducer.—The problems encountered in considering the design of the film reproducer were considerably different from those met in the recorder. Since the unit was to operate on the ground only, weight and mechanical filters were no limitation. In the case of the recorder, the recording image could be located on a solid rotating drum or sprocket. However, in reproducing it was necessary that the light beam cover nearly an inch in width of the film containing the sound tracks, and then be projected on 13 photoelectric cells. This automatically eliminated a rotating type of scanner assembly, and required the use of a fixed gate which is inherently a source of flutter trouble.

A system was evolved whereby a belt drive to a heavy flywheel mounted on the film drive sprocket shaft was used with a curved gate located adjacent to the drive sprocket. In order to obtain uniform tension on the film as it passed over the curved gate, an eddy current type of drag was devised. The nature of this film propulsion device was such that it introduced very little flutter in the low-frequency bands, which is the requirement that must be met for the analysis of relatively high frequencies through a narrow band pass filter.

One of the problems that required a good deal of thought was the providing of means for maintaining the same frequency response within 5 per cent over the 13 channels between the frequency range of 5 and 3000 cps. An optical system operating over so wide a field both in the recorder and reproducer introduced variations in output level at the higher frequencies among the tracks considerably greater than the requirements permitted. Electrical equalization in the reproducing amplifiers appeared totally impractical, since it completely disrupted the phase relations among the various tracks. Phase correction networks appeared impractical, for as time went on it was conceivable that the frequency characteristics might shift for one reason or another, and this would require a redesign of the phase correcting networks. The problem was finally solved by the introduc-

tion of an optical method of correcting the frequency characteristic and adjusting the phase relation among the tracks.

Conclusion.—In conclusion, many thousands of tests have been recorded with this type of equipment. We have been advised that the flight test time has been reduced to approximately one-fiftieth of that required by other methods of test, and in addition the final analysis of the information is available for consideration a day or two after the flight test has been made.

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AIRPLANE VIBRATION RECORDER*

J. C. DAVIDSON AND G. R. CRANE**

Summary.—This paper describes a portable film recorder capable of simultaneously recording 13 variable-area tracks on 35-mm film. It is intended for use in the analysis of airplane vibration or similar studies in which it is desirable to record disturbances (mechanical, acoustical, or electrical) from a number of sources in such a manner that the resultant record can be analyzed for frequency, amplitude, and phase relation. Film speeds of 12, 6, or 3 in. per sec are available.

In the first paper of this series,¹ the basic problems involved in the application of film recording technique to the recording of test data for airplane vibration work were discussed in some detail. The theoretical considerations were developed, and the requirements of equipment were outlined. These items may be briefly summarized as follows:

(1) The over-all equipment must be as small as possible, reasonably light in weight and sufficiently rugged to withstand handling and installation in airplanes for flight test work.

(2) The optical system must provide 13 variable-area records on standard 35-mm film, utilizing all of the space between sprocket holes, and give sufficiently good definition to allow all records to exhibit approximately the same quality and definition of image. The optical efficiency must be such that the recording lamp may be operated at a point low enough to insure a long and dependable life. Provision must be made for monitoring all 13 tracks simultaneously before and during the take.

(3) As previously discussed,¹ the film motion must be very good with respect to the lower flutter rates, and the film path must be so designed as to permit simple threading and easy removal of film magazines. Movement of the film must be independent of accelerations in any direction, which are frequently experienced in the course of airplane flight.

(4) Interchangeable film magazines are required to contain 200 ft of film. They must be simple to thread, as small as possible, and contain a device to insure that the threaded film loop on the take-up spindle cannot be pulled off while handling.

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** Electrical Research Products Division of Western Electric Company, Hollywood.

(5) The light valve shall be of sealed construction for protection against dirt, and the 13 ribbons shall have uniform characteristics with respect to dimensions, placement, sensitivity, and frequency characteristics. The light valves shall be interchangeable in the recorder without requiring adjustments.

(6) Equipment shall operate satisfactorily over a temperature range from -40 F to +120 F.

(7) The motor driving this equipment shall operate from a nominal 24 v, d-c, and shall provide adequate speed regulation to meet the requirements. It shall attain stable speed as rapidly as possible and be provided with dynamic braking to insure fast stops, and thereby conserve film.

(8) Three recording speeds shall be provided: namely, 12 in., 6 in., and 3 in. per sec, with corresponding facilities for lamp current control.

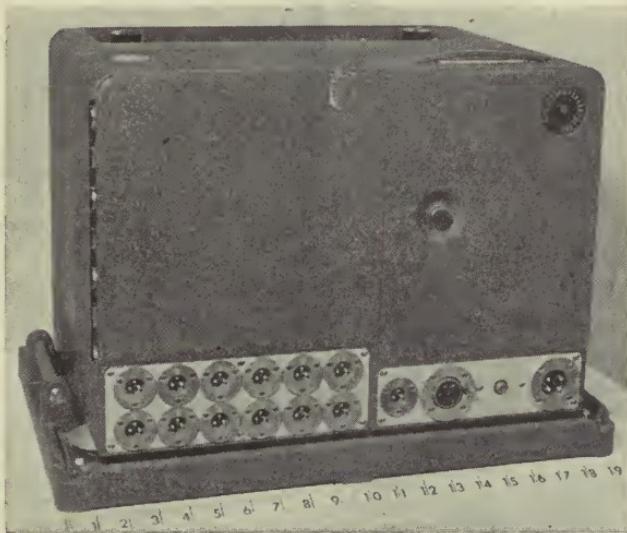


FIG. 1. Front view of recorder and mounting base.

(9) Several accessories are required which include a photographic slate to photograph automatically a slate number on each "take," a footage counter, a sequence switch for automatic operation, a film speed indicator, a continuous monitoring device, a remote control unit, and the usual miscellaneous operating controls.

It is obvious from the foregoing list of requirements that considerable equipment must be contained in a relatively small space, so it is not surprising that the assembly is somewhat crowded. However, most of the items have been designed on a unit subassembly basis, and the parts requiring inspection or adjustment have removable covers, or are otherwise made readily available.

The main recorder case, magazine, and the mounting base are shown by Fig. 1. They are magnesium alloy castings and all components within the case are designed to be as light in weight as possible. The over-all weight of the recorder, including a magazine and film, is 96 lb. The recorder is mounted on a base which contains shock mountings to protect it from severe vibrations. The base has handles for carrying or strapping in an airplane. Where space is at a premium

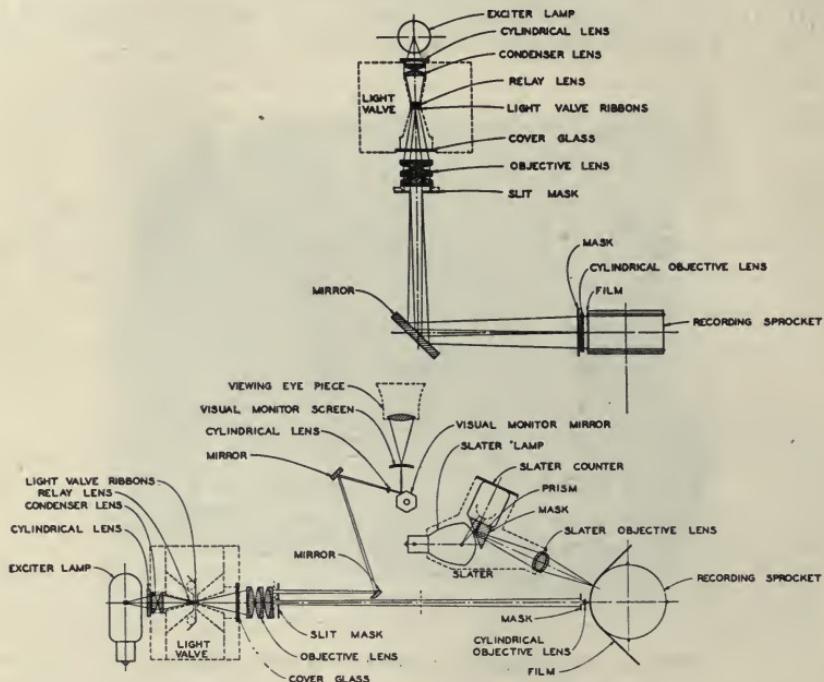


FIG. 2. Optical schematic.

the mounting base may be removed and shock protection provided for the recorder by other means. All electrical connections to the recorder are made through Cannon plugs located on the lower front surface of the main case.

The optical system is shown by Fig. 2. Light from the lamp is focused by the condenser lens located in the rear of the light valve to form an image of the filament at the ribbon plane. The filament image is diffused in the horizontal direction to avoid filament coil striations. This is accomplished by a cylindrical lens element mounted in the modulator and adjacent to the condenser lens when

the light valve is in place. A relay lens mounted in the light-valve pole piece serves to collect light and focus the condenser lens aperture into that of the objective lens. The objective is a high-quality lens which focuses an image of the light-valve ribbons on the film. A mask, which is placed directly in front of the objective lens, has a central rectangular opening, the horizontal edges of which are focused by a small cylindrical lens near the film to form the recording light beam on the film. This beam then appears as a line of light one mil high, extending across the width of the film and broken by the shadow images of the light-valve ribbons. The mask in front of the objective lens has a second opening, the light from which is collected by a mirror and used for monitoring purposes as explained later.

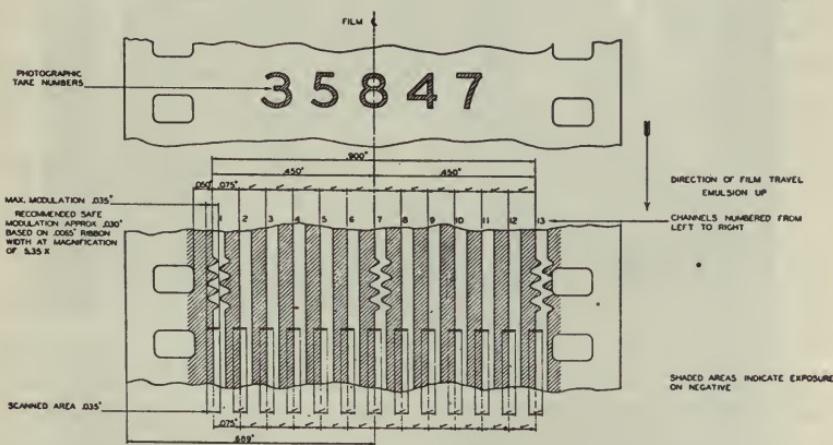


FIG. 3. Placement of 13 sound tracks on 35-mm film.

The resultant unmodulated sound tracks are shown by Fig. 3. This record is a negative in which the ribbons appear as clear traces approximately 32 mils wide and spaced approximately 40 mils apart. As the ribbons in the valve move, 13 variable-area tracks are thereby produced.

The multiple cord drive was adopted as the most satisfactory for the requirements imposed on this equipment. The motor speed is reduced in 2 stages of approximately 4.3:1 to drive a 40-tooth sprocket on which the recording is done. The cord drive has 7 parallel strands of approximately 0.040-in. braided cotton cord which run in half-round grooves in each small pulley and lie on a flat surface of each large one. One continuous piece of cord is used and an idler pulley

provides for the crossover strand from the inside edge of one pulley to the outside edge of the other. The large pulleys have relatively low mass, and the belts are sufficiently tight so that they exhibit very little compliance. Consequently, there is little tendency to generate troublesome flutter. This flutter is measurable, but it is of relatively low magnitude and sufficiently high rate to make it negligible in this application. The relatively low rotating masses also

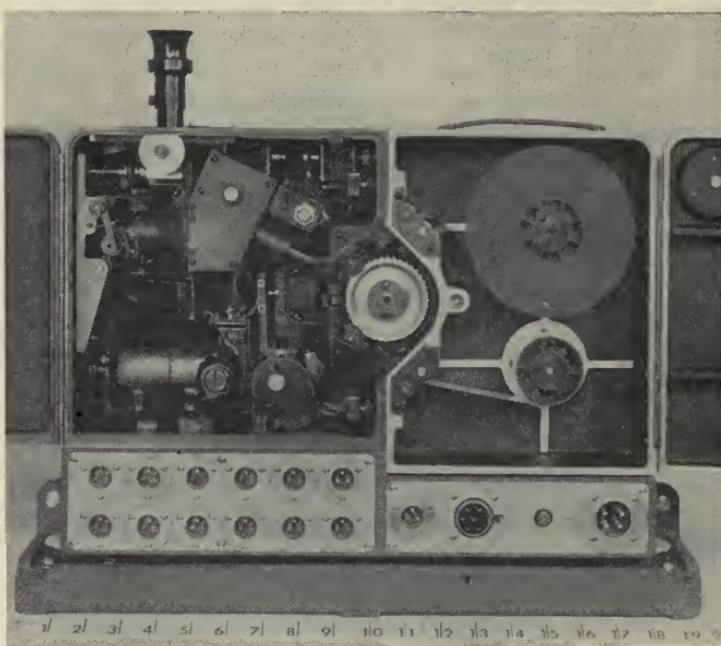


FIG. 4. Front view with recorder and magazine doors open.

provide a maximum of freedom from flutter produced by external accelerations of the equipment in flight.

The splicing of these belts presented an interesting problem, and we were unable to find a supplier who would undertake to splice them in a manner in which the splice would be equal in flexibility and diameter to the rest of the belt. A technique was finally developed for braiding the ends of the cord strands in a manner in which the laps are staggered, and the splice is essentially identical in diameter, flexibility, and strength to the remainder of the cord. These belts are prestretched before splicing, so that tightening after installation

is rarely necessary, because the multiple strands give sufficient friction without requiring excessive tension.

The 3-speed requirement was met by using change gears between the motor and a counter shaft. The flutter caused by gear disturbances is relatively high in frequency, and the amplitude is such that no trouble is experienced from this source. This, of course, partly results from the fact that more flutter may be tolerated at higher rates, as previously explained.

The film path is shown by Fig. 4. The film is held on the recording sprocket by 2 ball-bearing pad rollers, which are the only operating controls in threading. The upper roller has flanges which guide the film onto the sprocket and control film weave to within \pm one mil. The lower roller has a central section of rubber which causes the film to be pressed against the sprocket just ahead of the point where the film leaves the sprocket. This serves 2 purposes: It holds the film against the sprocket with sufficient friction so that displacements of the film owing to sprocket-tooth action tend to be attenuated by frictional damping. This action, combined with the proper choice of sprocket diameter relative to film pitch, keeps the generation of sprocket-hole flutter to a minimum.

A second advantage of this roller is that it makes a critical adjustment of the film take-up tension unnecessary even though this sprocket normally operates as a holdback sprocket. Each magazine provides a light tension on the feed roll, and it was found that as the diameters of the feed and take-up rolls interchange, a condition may arise where the film tension on either side of the sprocket may become approximately equal. Under this condition, it is obvious that considerable instability would be possible since the sprocket teeth are somewhat smaller than the sprocket holes. The action of the rubber roller is such that the film remains at all times in the position on the sprocket corresponding to normal operation as a holdback sprocket.

This film movement has the additional advantage of being extremely simple for threading in conjunction with the removable magazines. This film pulling arrangement has been found to be quite reliable and has operated satisfactorily in this application.

The flutter measured on this equipment has been found to be of the order of ± 0.1 per cent at rates below one cycle per second range, but in this range it is largely a function of the constancy of the supply voltage. From one to 10 cycles per sec, flutter is generally less than ± 0.1 per cent and gradually climbs at higher rates to a maximum of

about 0.25 per cent at the sprocket-hole rate, which is 64 per sec at a film speed of 12 in. per sec.

The film magazines have been designed to be as rugged as possible and are interchangeable on the recorder without affecting flutter or the film position on the sprocket. They contain 2 light-traps as the film goes in and out, and the reel centers are spaced as close together as possible to take advantage of the fact that the diameter of one roll in-

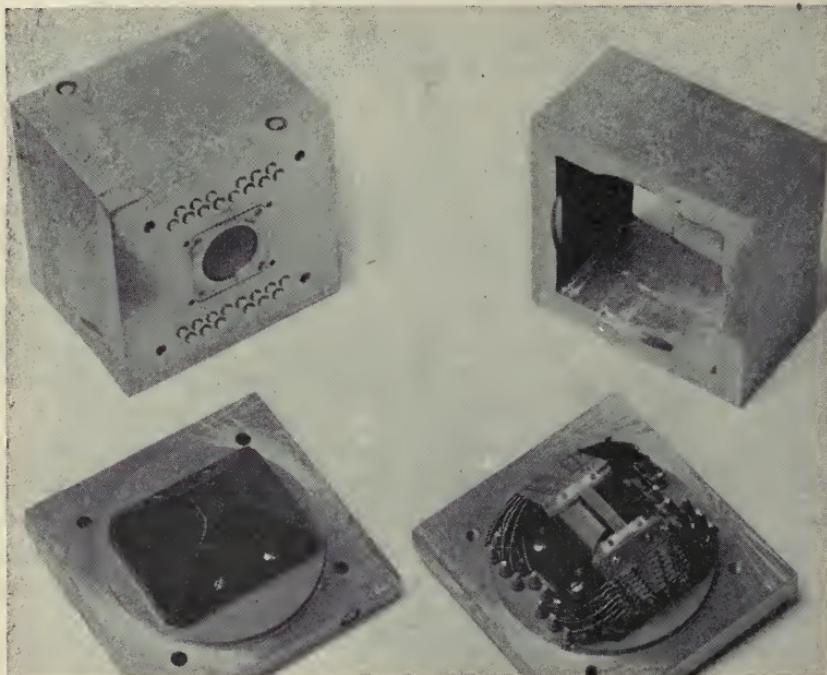


FIG. 5. Sealed assembly and views of 13-ribbon, permanent magnet light valve.

creases as the other decreases. They provide for slightly over 200 ft of film, and a manually operated dial on the door may be set as an indication of the unexposed film footage within the magazine. One unique feature of this magazine is a ball-and-wedge type of ratchet contained in the take-up assembly. Since these magazines are loaded in a darkroom, it is essential that the return film loop anchored on the take-up spool shall not be accidentally unrolled or loosened, which would thereby cause take-up failure.

The light valve developed for this application is shown by Fig. 5. It consists of a permanent magnet in the form of a hollow square and

2 end plates containing pole pieces between which the 13 light-valve ribbons are strung. These ribbons are the standard Western Electric light-valve ribbons, made of duralumin, which are 0.5 mil thick by 6 mils wide. These ribbons lie in precise grooves cut in 2 ivory bridges which determine the ribbon positions. The ribbon ends are clamped in a manner similar to that used in sound recording light valves, and the ribbons are tuned to approximately 6000 ± 100 cycles. The valve is used sufficiently below resonance that it becomes essentially a stiffness controlled device. The variations in individual ribbon sensitivity are held to ± 0.8 db, and frequency characteristics up to 3000 cycles are held within ± 0.4 db.



FIG. 6. Recorder equipped with insulating cover for low temperature operation.

These valves are assembled and then magnetized by means of special equipment and are not intended to be opened for any reason except by the manufacturer. Experience has shown that these valves are extremely stable and since they are well sealed, they require no attention whatever unless a ribbon is burned out. The amplifier equipment used to feed the valve is usually provided with a limiting device so that the ribbons cannot be accidentally damaged. As previously described, the side of the valve toward the lamp contains a condenser lens assembly. A wedge-shaped section of a spherical lens is mounted in the rear pole piece. The other end plate of the valve, which faces the objective lens, is provided with a cover

glass. All glass surfaces are coated to provide for maximum transmission and minimum reflection.

Operation at low ambient temperatures requires that the recorder be supplied with a source of heat. Therefore, several feet of a flexible, spun glass insulated heating element are mounted in the rear of the recorder to distribute the heat. A thermostat automatically energizes this heating element when the temperature falls below 40 F, but it is fed through relay contacts designed to prevent the heater

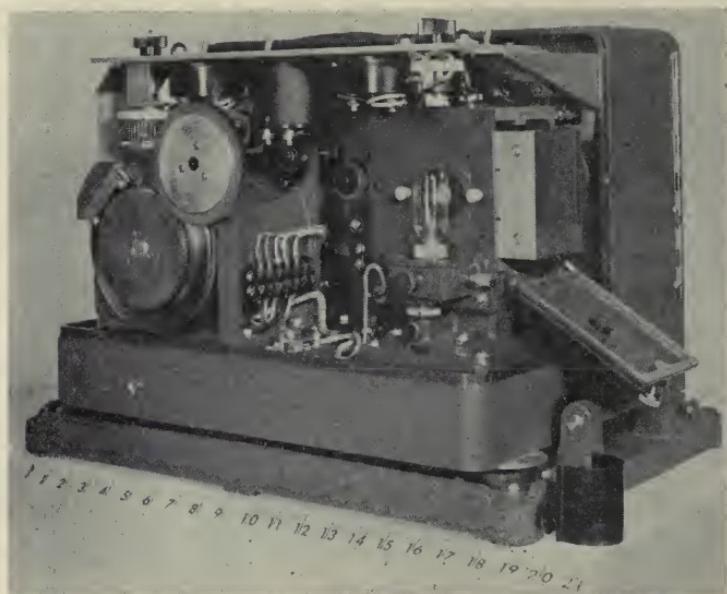


FIG. 7. Rear view of recorder showing drive mechanism and the modulator with its door open for access to the light valve.

from being energized during a recording period. This is done to prevent a change in motor speed which might be caused by the added load of the heater coming on the battery. As shown in Fig. 6, a heavy blanket type of cover is furnished to conserve heat, and it contains hinged flaps to give access to operating controls and indicating devices.

The motor and gear drive are shown by Fig. 7. The d-c driving motor is shunt wound, with manual speed control, and operates normally at 1800 rpm from a 24- to 28 $\frac{1}{2}$ -v source. The field is designed so that it may be left continuously across the 24-v line without

excessive heating. This is done to facilitate switching circuits which provide for dynamic braking when the motor is stopped, thereby reducing wasted film to a minimum at each operation of the recorder. The acceleration and deceleration are such that the total film loss per take is approximately 1.5 ft at 12 in. per sec, and proportionately less at the lower speeds.

The motor has ball bearings and silver-carbon alloy brushes to re-



FIG. 8. Top view of recorder showing control panel and indicating devices.

duce possible variations in brush contact drop at the commutator. An eddy current drag disk is mounted on the rear of the motor for the purpose of providing a well-damped, constant load which is large compared with that of the recorder. This tends to attenuate minor speed changes which would otherwise result from slight load changes in the recorder caused by the various mechanical operations that occur during the recording cycle. The motor is mounted on a sub-base to form a subassembly with the countershaft. This provides fixed centers for the 3 sets of change gears previously referred to. These gears are bronze running against phenol linen and are ac-

curately cut with respect to center distances and concentricity. The 3 sets of gears are interchangeable without readjusting the mesh, and each is mounted by 3 screws to a hub. A small door is provided in the rear cover of the recorder to permit accessibility for changing these gears without removing the cover.

The various accessories will be described briefly. Some of these have been added to more recent equipment manufactured as a result of operating experience. In order to identify various takes, a pair of Veeder counters were used. As shown by Fig. 8, one of these is visible from the top of the recorder, and the other is contained within the slater which is automatically photographed on the film at the end of each take. The circuits are arranged to provide a time delay so that the recorder is stopped before the slater operates. A 12-v fluorescent lamp is used, and the filament is heated during the recording period and flashed by means of a relay which connects a charged condenser to the anode of the lamp. This produces a flash of short duration as the condenser discharges.

A footage counter, also visible on top of the recorder, is the same type as used in the slater. It is driven by a cam mechanism and indicates feet of film.

A sequence switch is provided which performs the function of stopping the recorder after a predetermined footage of film has been run. The sequence of operation is started by a momentary operation of the start switch, after which the sequence switch controls several relays which, in turn, control the motor, recording lamp, and the slating operation. The sequence switch, consisting of 3 cams operating microswitches, is driven by small change gears so that standard take lengths of approximately 3.5, 5, 7, or 10 ft may be obtained. A long take consisting of any multiple of the standard take may be obtained by holding the start switch closed.

A small remote control unit is provided which contains a momentary start switch, an extension take counter, and signal lights for slate and operation. It also provides for an additional extension of the start switch which may be a small, simple momentary switch that may be attached to the control stick. It is sometimes necessary for the pilot of a small plane to control the recorder also. This control unit may operate with any desired length of cable since it contains only relay control circuits.

The visual monitoring device consists basically of a small screen located at the top of the recorder, on which is focused an image of the

light-valve ribbons. This image is swept across the screen by means of a rotating, 6-sided mirror. With this facility, any steady, repetitive signal impressed on the ribbons may be made to appear as a standing wave pattern on the screen for viewing. This facility is not intended to provide a high order of accuracy, but primarily as an indication of the nature and amplitude of the signal being impressed on the ribbon. Two guide lines are provided on the monitor screen to assure the operator that the valve is in its proper position and that all ribbons are intact.

The rotating mirror is driven by a d-c shunt motor, and the mirror speed may be adjusted by a control knob over a very wide range. This speed adjustment makes use of a right-angle friction drive in which the driving disk may be moved relative to the driven disk on the prism shaft. The lower limit of observation for a standing wave pattern is of the order of 25 cycles. This is determined primarily by the number of wave lengths desired and flicker which results from the lack of persistence of vision at slow rotational speeds. The screen may be slid to one side and replaced by a viewing eyepiece which gives greater magnification of a smaller field, but may be moved to view any track.

The film speed is indicated by a vibrating reed type of meter having 5 reeds with the central reed indicating proper speed and tuned to 60 cycles. A commutator on the motor shaft provides 60-cycle, interrupted d-c to the meter when the motor is running at 1800 rpm. This meter permits the motor speed to be adjusted with an accuracy of at least one-half per cent.

The control panel of the recorder contains the usual operating controls, such as a line switch, line voltmeter, pilot lamp, recording lamp meter, lamp rheostat, and "Operate" signal lamps. The "Slate" signal lamp, frequency meter, monitor control switch, and start switch previously referred to also appear on this panel.

This recorder is intended to use Eastman Kodak 1371 film, the characteristics of which are described elsewhere.¹ The negative is used for all purposes of analysis, and no prints are ordinarily made. The density for the black portions between the tracks is chosen on the basis of minimum cross-modulation in accordance with established techniques used for variable-area sound recording. It has been found that for the requirements of this application, the visual, diffuse density should be approximately 1.1 but it is not critical. The lamp current required to produce this density is, of course, determined by

lamp tests under the particular processing conditions available, but the lamp current is usually of the order of 3.7 to 3.9 amp, which is sufficiently under the normal lamp rating of 4 amp that a long lamp life may be realized. A development gamma of 3.75 is recommended, which is not critical but is included in the determination of optimum density for minimum cross-modulation.

This recorder has been in service by several users and is reported to have materially reduced the time required for flight tests. In addition, the record produced is a permanent one, and has the significant advantage of being available for rapid and accurate electrical analysis which results in additional information and savings in time. The equipment for the reproduction of the film made on this recorder is described in another paper.²

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AIRPLANE VIBRATION REPRODUCER*

G. R. CRANE**

Summary.—This paper describes a reproducer set designed for use in the reproduction for analysis of multiple track film recordings. It is capable of reproducing simultaneously 13 variable-area tracks recorded side by side on standard 35-mm film. Recorded signals between 5 and 3000 cps are accurately reproduced and may be analyzed for frequency components, amplitude, and phase relation.

The reproduction of the multitrack film made on the airplane vibration recorder¹ represents a significant advance as compared to other types of oscillographic records commonly used to record airplane vibration data and similar phenomena. This advance lies in the provision for accurate electrical reproduction of the original permanent record which may be analyzed by the use of accurate analyzing equipment already available. Some of the aspects of such analysis, with special reference to performance of the reproducing device, have been described in the first paper of this series.² It is, of course, also possible to listen to the audible reproduction in case that is of interest. The sound tracks on the film may be analyzed visually if desirable, but for other than check purposes, the electrical analysis is generally of far greater value.

Basic considerations for both the recording and reproducing equipment have been discussed in the first paper of this series,² and the general requirements for the performance of the reproducer are outlined. These requirements, together with the accessory devices, may be summarized as follows:

- (1) The optical system and film moving devices shall be such that all 13 of the sound tracks may be scanned in line, and the light from each track conducted to a separate photocell whose output is, in turn, connected to a suitable PEC amplifier.
- (2) The reproduced signal from each sound track, taking into account both the optical and electrical elements, must have a high order of uniformity with re-

* Presented Oct. 17, 1944, at the Technical Conference in New York.

** Electrical Research Products Division of Western Electric Company, Hollywood.

spect to linearity, frequency characteristic, phase relationship, and output level relative to the original input signal to the recorder light valve.

(3) The film motion must be such that excellent performance can be maintained at low flutter rates with somewhat greater amounts of flutter being permissible at higher rates. It is also required that this performance be held for film speed of either 12 in. per sec or 6 in. per sec.

(4) It is required that adequate power supplies be provided to supply the power requirements of the reproducer and associated PEC amplifiers so that variations in load and line voltage will not affect the film analysis. Means must also be provided for switching any one of 5 output circuits to any one of the 13 PEC amplifier outputs with freedom from crosstalk or other electrical interference.

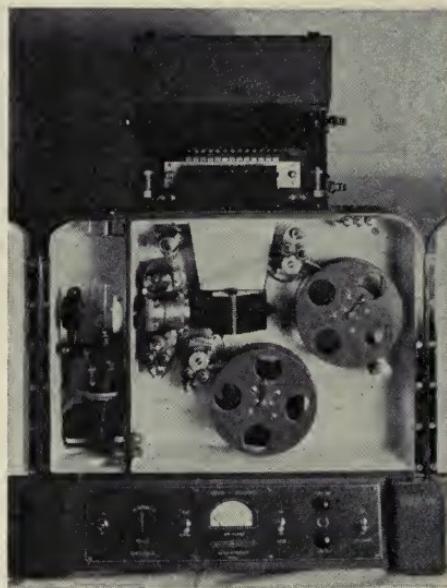


FIG. 1. Front view of reproducer showing film and lamp compartments.

(5) For convenience in operation, several accessories are required. A switch is required for supplying a-c to the exciter lamp as a means for quickly lining up channels. A small roller contact assembly is required at the scanning point so that when a film loop is notched at the splice, a relay circuit will provide a contact to prevent transient disturbances in the analyzing equipment. The same contact assembly must also provide a facility whereby a recording analyzer may automatically be started at one passage of the splice, record for one trip around the loop, and be automatically shut off by the second passage of the splice.

Since this equipment is intended for use on the ground only, weight and bulk are no particular disadvantage. The reproducing equip-

ment is designed in 3 major units: the reproducer assembly which contains all of the elements for film pulling and scanning, an amplifier cabinet containing 14 amplifiers, and a relay rack containing regulated power units to supply the reproducer and amplifiers.

As shown by Fig. 1, the reproducer consists of a cast housing containing the film moving parts. Considering the requirements for film movement and scanning, it was determined that a constant speed sprocket pulling the film across a fixed, curved gate would meet these requirements, provided that the film tension is held very constant. The latter is accomplished by passing the film over a roller located just above the gate, the film being held in contact with the roller by means of a second pressure roller. To this roller is attached an eddy current drag disk of copper, approximately 6 in. in diameter and rotating in a space between 2 sets of permanent magnets. The relative positions of these magnets may be altered in order to change the total magnetic flux and thereby the film tension. A 2-position control is provided with this assembly so that the flux may be altered to give the same effective film tension at either 6 in. or 12 in. per sec, since the drag is proportional to speed for a given flux.

The curved gate is constructed of hardened steel, highly polished on the film contacting surfaces. The abrasive action of the film base serves to maintain a high polish. The contacting surface is relieved over most of the central area and supports the film only in 4 small areas between the sprocket holes where abrasion of the film base will not be in areas useful for scanning. The film is also supported at the edges, permitting a slot to be cut across the gate at its center between the sprocket holes to pass light for scanning.

Film guiding is accomplished by adjustable flanges on the eddy current drag roller. The bearing design is such that end play in the roller shaft may be virtually eliminated. A small roller arm assembly presses the outer race of a ball bearing lightly against the edge of the film at the scanning point, but exerts sufficient pressure to cause the film to run against one guide flange. This minimizes weave, even though the film is narrower than standard owing to shrinkage. Feed and holdback sprockets are provided so that there will be free loops of film into the drag roller and out of the sound sprocket. These sprockets are driven by a silent chain which also drives the take-up. The main case contains an opening with guide rollers for passing the film in and out of the case so that long film loops may be run on suitable loop racks.

The sound sprocket just below the curved gate is rigidly connected to a shaft carrying a massive flywheel which is driven by a thin, flat linen belt directly from the motor and pulley assembly. This is shown by Fig. 2. The relatively large mass of the flywheel and extremely low compliance of the belt prevent any natural period of mechanical oscillation which would be troublesome from the flutter standpoint.

The driving motor is a 3-phase, 6-pole synchronous motor running at 1200 rpm. A stepped pulley and belt grooves on the flywheel pro-

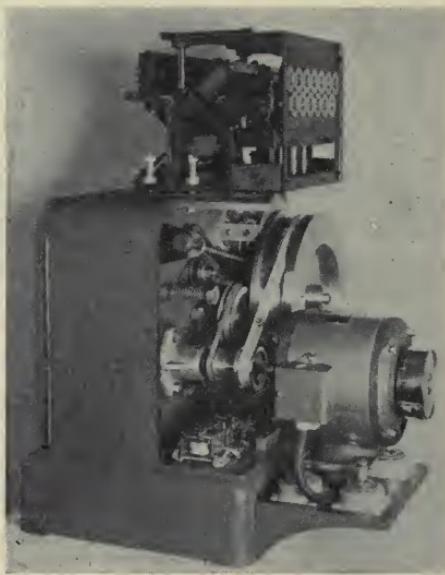


FIG. 2. Rear view showing drive mechanism.

vide for a film speed of either 6 in. or 12 in. per sec. Provision is made for mounting special 250-ft reels within the reproducer, and the take-up reel is driven through a felt friction clutch. The large mass of the flywheel effectively prevents any minor disturbances, such as take-up troubles, from disturbing film motion within measurable limits.

As shown by Fig. 3, the main operating controls are located on a control panel in the base of the machine and consists of the 3-position switch for the lamp for operating it either on a-c or d-c. A lamp rheostat and meter are provided and also a lamp "Hold" switch similar to current practice in certain motion picture apparatus. This reduces

the lamp voltage when the machine is not running so that heat from the lamp will not constitute a fire hazard.

The relays which perform the one trip around the loop sequence previously mentioned are energized from a 12-v source through the right-hand switch marked "Auxiliary." Two push buttons are provided on the panel for this automatic cycle, and are marked "Start" and "Stop." The start button may be pushed at any time. The relay sequence is such that the next passage of an edge notch locks up a mechanical latching relay and starts the recording oscilloscope when

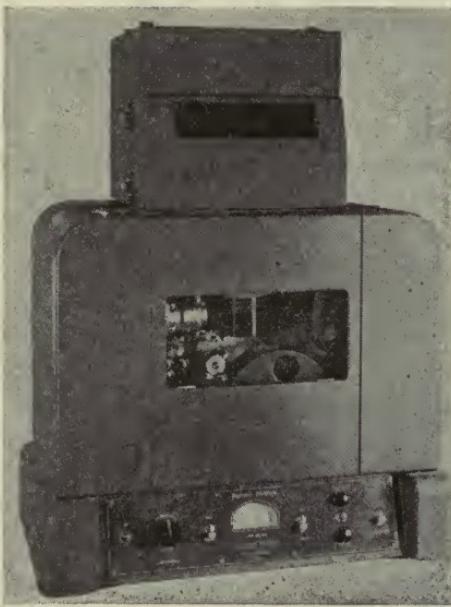


FIG. 3. Front view of reproducer.

it is properly connected to a receptacle in the rear of the machine. A time delay relay then transfers the function of the small roller switch at the film gate so that upon the next passage of the notch the unlatching coil of the mechanical latch relay is energized, the system returns to normal, and the recording oscilloscope is stopped. If it is desired to stop the cycle at any immediate position, this may be done by pushing the button marked "Stop." The film notch is that produced by the Bell and Howell Film Notcher commonly used in film laboratories.

The optical design of this reproducer presented an interesting

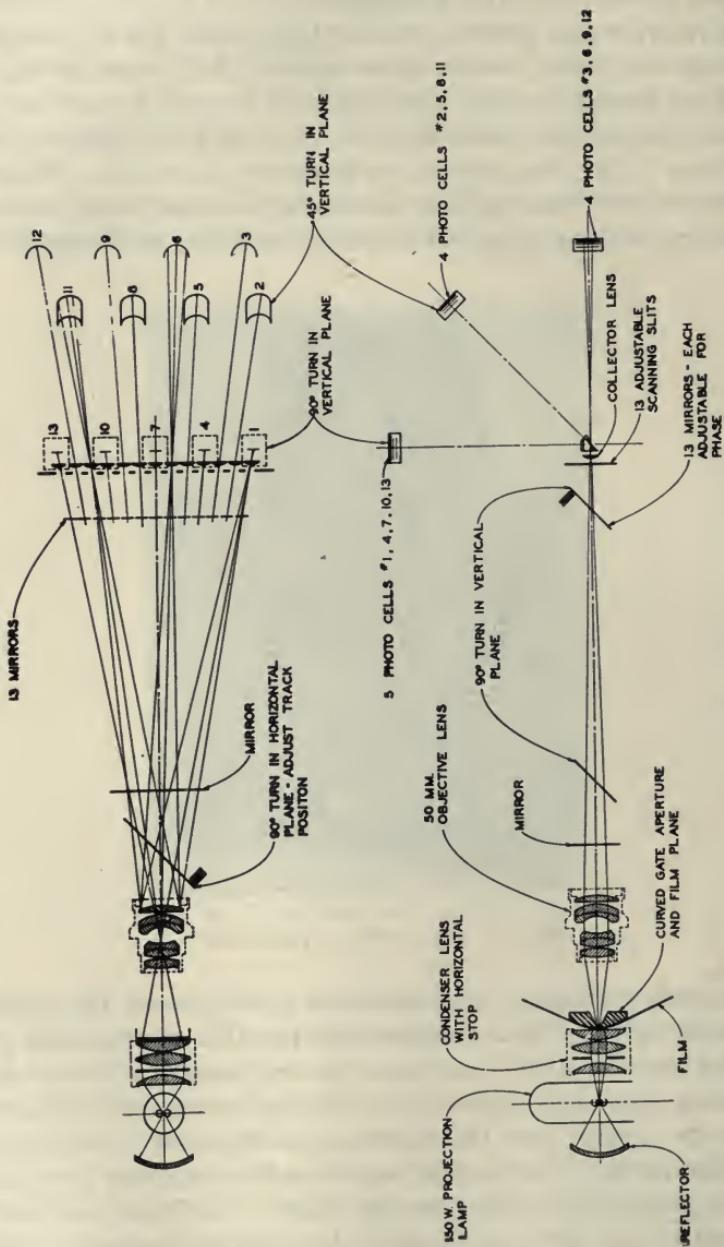


FIG. 4. Optical schematic.

problem, considering the requirements placed on the multiplicity of tracks covering the entire width of the film between sprocket holes. The optical system adopted for this design is shown schematically by Fig. 4.

The light source is a 120-v, 150-w projection lamp normally operated on voltage regulated direct current, but it may be switched to 120-v alternating current for quick line-up tests of the various channels. The light from the lamp passes through a condenser lens assembly having a horizontal stop, and the filament image is focused in the objective lens. A reflector behind the lamp increases efficiency in the manner common to most projection optical systems. The film is as close to the condenser lens as possible and is illuminated across the full usable width of the film. The objective lens forms an image of the film on a scanning slit assembly, the lateral position of the entire image being readily adjustable by the operator. The objective lens is used at an aperture of $f\ 3.5$.

To obtain mechanical compactness and permit short loop operation, the light beam is deflected by 3 sets of mirrors. The first mirror following the objective lens reflects the light beam toward the rear of the machine. The second mirror throws the beam up, and the third reflection is again toward the rear of the machine and onto the scanning assembly, which is mounted in the photocell assembly on top of the main housing. A screwdriver adjustment is provided on the first mirror which is used to displace the track images at the slit to left or right for over-all alignment in scanning.

Light from each track, after passing through the scanning slit, is collected by a small collector lens just behind the slit and applied to the photocells in such manner that the photocell cathodes receive an image of the objective lens. The image varies in intensity and not in area as the sound track image passes the slit. The assembly containing the scanning slits and associated optics, together with the photocells, is shown by Fig. 5. To conserve space the photocells are mounted in 3 banks, and in order for the light to reach two of these banks, it is necessary to reflect the light via small prisms. The photocells are wired to plugs on the back of the assembly where connections are made to 13 concentric cables from the PEC amplifier cabinet. Considerable care is exercised in the wiring to maintain identical electrical characteristics in each photocell circuit.

The photocell assembly is mounted by means of 4 threaded bushings which are used to adjust the over-all length of the optical path

between the objective lens and the scanning slits. This determines the magnification of the film image at the scanning slits. These bushings are also used to adjust the over-all azimuth of the slit assembly.

The RCA 929 vacuum photocell is used, and was chosen primarily because of its high order of linearity and relatively good sensitivity. Each cell is capable of being moved laterally to permit the spot of light falling on the cathode to be placed so that the anode rod will not intercept the light and thereby reduce output or introduce microphonic noise.

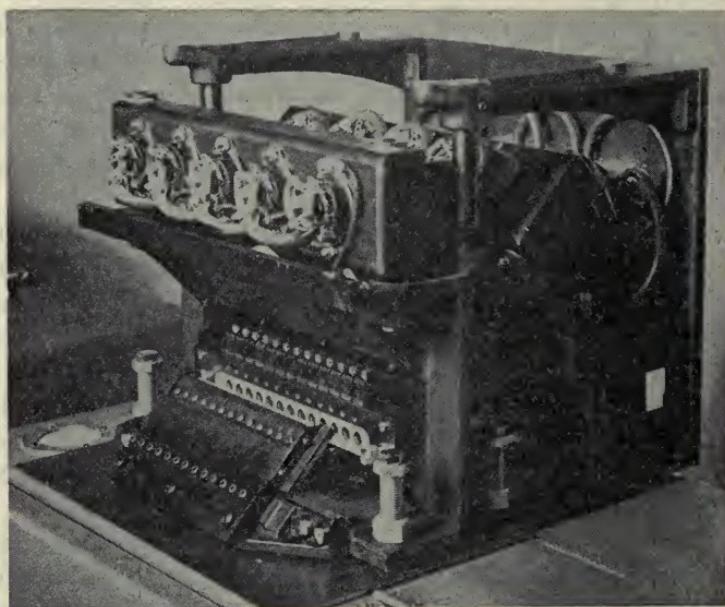


FIG. 5. Scanning and photocell assembly.

A high-quality photographic lens is used as the objective, but in this system it is at a disadvantage, being used at a magnification of 5 to 1, and does not have equal resolution over the required field. Likewise, the recorder objective lens used to record the tracks does not resolve all track edges equally. To meet the requirement of uniform over-all frequency response from all tracks, some compensation is obviously necessary. Equalization of the amplifiers brought up the problem of phase displacement as a function of frequency and would have introduced considerable complexity in design, bulk of equipment, and a lack of flexibility in the event the optical elements were

readjusted or altered. Therefore, it was decided to adjust the scanning slit height as a means of compensation, since the frequency characteristic curves vary with slit height in a similar manner to changes in effective lens definition. Therefore, one edge of the 13 scanning slits was made common and determines over-all azimuth, but the other edge of each slit is variable and is adjusted to give the same frequency characteristic for each track, including both reproducer and recorder optical systems. It is obvious that as one slit edge is moved, the effective center for scanning is shifted by one-half the amount so that phase compensation is necessary. Therefore, the third and last reflection before the light reaches the slits is provided by 13 separate mirrors, each of which corresponds to one of the 13

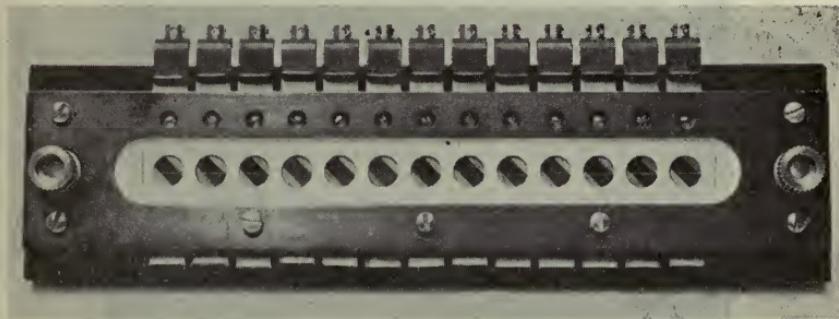


FIG. 6. Scanning slit assembly.

tracks. By adjusting the angle of each mirror, the phase relation of each track may be accurately adjusted. This adjustment is made by small screws which bend the mirrors very slightly. This meets the unusual requirement that the reproduced signal from any 2 tracks must be capable of adjustment for phase relationship to within ± 10 electrical degrees at a frequency of 3000 cycles.

The scanning slit and mask assembly, shown by Fig. 6, is readily visible and accessible on the front of the PEC compartment, and may be removed as a unit and replaced without disturbing line-up adjustments. Either end of each slit may be masked for proper scanning by means of wedge-shaped masks, top and bottom, which can be pushed in or out of the slit area. The slit width is adjusted by a capstan screw opposed by a spring and provided with lock screws to insure against accidental change of adjustment.

The scanning masks are usually adjusted by reproducing a test film

made with all tracks modulated with a sine wave signal between 95 and 100 per cent, or an amplitude of approximately 32 mils. The masks are then set to be just clear of clipping as the wave form is viewed on an oscilloscope. It is recommended that the recording levels be controlled so that the ribbons are never modulated over 80 per cent, or approximately 26 mils. This leaves a margin of about 6 mils, or ± 3 mils for combined weave in the recorder and reproducer. The phase adjustment may also be made by means of a cathode ray

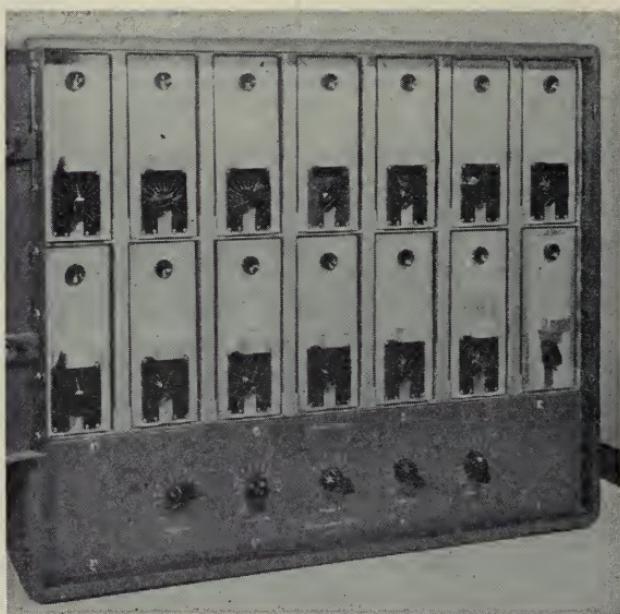


FIG. 7. Amplifier cabinet.

oscilloscope. Film having all tracks modulated in phase by the same sine wave frequency is reproduced. The oscilloscope has one set of plates connected to one track output, and the other plates to each one of the other track outputs in succession. Each phase adjusting mirror is then set for a line pattern indicating precise in-phase relationship.

By means of these facilities it is possible to adjust the equipment so that the over-all frequency characteristic obtained at the output of each PEC amplifier is flat within ± 0.5 db for constant voltage input to each light-valve ribbon. An over-all signal-to-noise ratio of

approximately 32 db is available at the output of the PEC amplifier, this figure being based on 80 per cent modulation of the recorded tracks.

The amplifier cabinet is shown by Fig. 7. It contains 13 PEC amplifiers, each of which makes all connections through small plugs and jacks when it is pushed into any compartment in the cabinet. The output of each of these PEC amplifiers is connected to one point on each of the 5 selector switches located in the base of the amplifier cabinet. By means of these 5 switches, any one of 5 output channels may

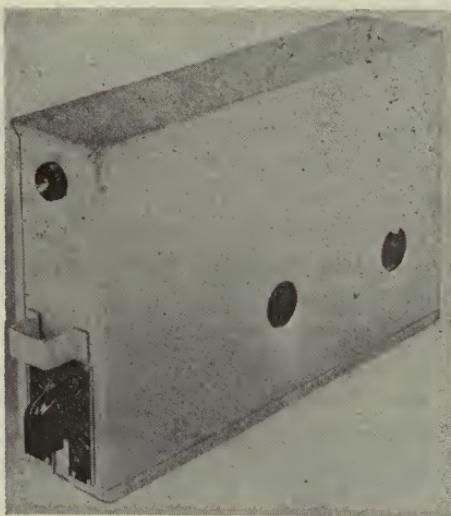


FIG. 8. Interchangeable PEC amplifier unit.

be quickly switched to any amplifier output. Special care has been taken in the design of these switches to prevent electrical crosstalk and other sources of noise.

Fig. 8 shows one of the PEC amplifiers which has 2 stages with feedback and a nominal output of 100,000 ohms which is the normal input impedance of the analyzing equipment. It is provided with facilities for adjustment to identical frequency characteristics as required to compensate for optical and film losses in the recorder and reproducer as previously described. All amplifiers are mechanically and electrically interchangeable and each may be used in any of the 13 positions. Each amplifier has a gain control which permits the signal output from each track to be equalized. This may be quickly

done without film by throwing the reproducer lamp to a-c and using the 120-cycle signal resulting from lamp modulation. For more precise measurements, test films made with constant input to each light-valve ribbon should be used for the adjustment. A fourteenth amplifier is provided to reduce the 100,000-ohm output impedance to 600 ohms. It may be patched to any PEC amplifier through jacks at the rear of the amplifier cabinets.

The various power supply units will not be discussed in detail except to point out that they are the self-regulating type so that their output voltages, which supply this equipment, will not vary more than one per cent for line voltage variations of 105 to 125 v. This insures that line voltage fluctuations will not produce errors in measurements during the use of this equipment.

This reproducer has been found to operate very reliably under field conditions with a minimum of adjustment or maintenance. At the same time, it offers sufficient facilities for adjustment to meet inadvertent departures from standard test conditions. When used in conjunction with a suitable analyzer, it permits rapid determination of the vibration conditions being tested.

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- ² FRAYNE, J. G., AND DAVIDSON, J. C.: "Application of Sound Recording Techniques to Airplane Vibration Analysis," *J. Soc. Mot. Pict. Eng.*, 44, 1 (Jan., 1945), p. 31.

THE TEACHING OF BASIC ENGLISH BY MEANS OF FEATURE FILMS*

A. BETTY LLOYD-JOHNSTONE**

Summary.—The theme of this paper is the translation of foreign language superimposed motion picture titles into Basic English. Interest in learning to speak Basic English by the peoples of the world can be aroused by distributing the regular Hollywood feature films with their original sound tracks, and with superimposed titles in the language of the people who will view them. A translation of the foreign superimposed title into Basic English would also be printed under the foreign title. Such a method of transmitting the dialogue of motion pictures to foreign-speaking audiences would unconsciously arouse an interest in learning English.

The main theme of my paper is: the translation of foreign language superimposed titles into Basic English.

I believe that we have a great opportunity for the teaching of Basic English by the use of our regular feature films. The motion picture is entertainment, and any feature picture that does not entertain defeats its purpose.

Foreign peoples want to see our films because they want entertainment. The vast majority of people, of whatever nationality, do not want to be educated in the sense that they want to go to school. They do not mind learning if the operation is painless. We would like the peoples of the world to learn Basic English. But we cannot insist that they do. The ideal situation would be that they would *desire* to learn English. How are we, then, to arouse their interest in English?

I believe that we can arouse this interest by sending our regular feature films to them just as they were produced in Hollywood, with the sound track carrying the dialogue in English, and with superimposed titles in the language of the people who are viewing the picture, just as we have been doing, but with a translation of the foreign title into Basic just below, or rather, just under the foreign title.

* Presented Apr. 19, 1944, at the Technical Conference in New York.

** Office of Strategic Services, Washington, D. C.

You may be among those who do not approve of Basic English. Neither do I, if it is to supplant the English of the great novelists and poets. But Basic as an auxiliary language for other peoples, yes. *Time Magazine* of Oct. 4, 1943, carried a story entitled "Whose Basic?" Dr. Lin Mou-Sheng, Chinese scholar, author and editor, asked two pertinent questions: "Why Basic English?" and "Why not Basic Chinese?" *Time* says: "Dr. Lin tempered his proposal with a compromise suggestion; let each of the world's most widely used languages be reduced to Basic and universally taught."

It is already evident that other peoples will attempt to teach, or have their language taught as an auxiliary language. English-speaking peoples, as well as many foreigners, suggest that English become, if not the universal, at least one of the global languages.

We are all agreed that we must have an international language if the peoples of the world are to learn to know one another. Winston Churchill favors Basic English. He told us in his Harvard speech on September 6, and I quote: "I do not see why we should not try to spread our common language even more widely throughout the globe, and without seeking selfish advantage over any, possess ourselves of this invaluable amenity and birthright." He went on to say, and again I quote: "Some months ago I persuaded the British Cabinet to set up a committee of ministers to study and report upon Basic English." A bit farther on in his speech he stated: "What was my delight when the other evening quite unexpectedly I heard the President of the United States suddenly speak of the merits of Basic English."

We are but one nation out of many that would like to hear our language spoken as an auxiliary, of course, the world over. The United Press carried a story dated from London, July 24, 1943, telling of a committee representing the Ministries of Education of Belgium, Czechoslovakia, Greece, The Netherlands, Norway, Poland, Yugoslavia, and the Fighting French, who, and I quote, "today recommended the establishment of English or French as a world language after the war—with a slight leaning in favor of English." The committee suggested that (1) English or French be compulsory subjects in higher forms of elementary schools of the European Allies; (2) that the teaching of English be strengthened as far as possible in all schools in view of the important part it will play in international intercourse; (3) that all publications intended for international reading be published either in English or French, or be accompanied by English or

French summaries; and (4) that only English or French be used at international meetings.

English will be widely taught throughout the world, but let us facilitate the teaching of it by sending out motion pictures with their original sound track, with the dialogue in English, and with the subtitle or superimposed titles in the language of the audience which is to view the picture, and directly under the subtitle a literal translation into Basic English.

Nearly all foreign films are shown with the original sound track and with the superimposed titles in English. Do we mind the French, Russian, or Spanish language if we do not understand it? Not at all. It is merely incidental sound and fits into the musical pattern. If a film is well produced and edited, the action is natural, and one scene leads into another, and if the superimposed title describes the action and it is well written, we know exactly what is going on. If English sound track is dubbed in, we are conscious, regardless of how well done it may be, that the lip movement is not synchronized with what we are hearing.

Let us try to analyze our reactions when we see and hear a foreign motion picture. How does dialogue spoken in a language with which we are unfamiliar strike us? The speech becomes mere sound and loses all literary value. As soon as speech is unintelligible it becomes incidental sound, thus leaving us free to follow the action.

This implies that we are on the road back to the days of silent films. But are we not deliberately reverting to the days of the silent film? The pendulum has swung away from the mad babel of sound that first met our ears when sound pictures were new. Silent films had reached a high artistic level, and would have gone still farther if sound had not arrived just when it did.

The true field of the motion picture lies in the word motion, not sound, although sound can further impressions we receive. But dialogue should be kept at a minimum, especially when films are designed for foreign audiences. The action in a motion picture can do almost anything that words can, and for the telling of a story, sound as speech is superfluous.

Speech in a film is purely a national medium. When dialogue is exploited the idiomatic speech employed is purely nationalistic. Only the nation for which a picture is made understands and appreciates the subtle quips and innuendoes. Such dialogue cannot be adequately translated, even though it is reproduced in the idiomatic

language of the country to which it is being sent. We do not all laugh at the same jokes, nor do we, that is, all the peoples of the world, have the same reactions.

The great development of the motion picture will be in its international implications, and such films will have a minimum of dialogue, or they will perhaps be silent. If dialogue is to be heard, it must be simple. Clear, simple dialogue will be effective when combined with music and incidental sound.

Dialogue for films intended for international purposes must be confined to words of few syllables, international words, words that are self-evident and, by their corresponding actions, speak for themselves. The sentences in the dialogue which will be translated in superimposed titles will carry a Basic English translation.

At present we have a backlog of pictures which can be sent abroad. Dubbing in foreign sound track is an added expense, and such dubbing defeats the teaching of English. Post-synchronized speech in a foreign language does little to gain us friends throughout the world.

There is no gainsaying the fact that through our motion pictures we have given the world, in many cases, an entirely false impression of America and Americans. We have certainly had it made clear to us that other nations live by other ideologies than our own. The peoples of other countries have been conditioned to entirely different beliefs.

We Americans, citizens of the United States, call us anything you will, are as nearly international in our mode of life as any nation in the world. Our people have their family roots in practically every country in the world. But these contacts are so weakened that our ideas are utterly foreign to other lands and other peoples.

There is always suspicion of the exotic, suspicion of anything strange, especially is there suspicion of peoples speaking other languages than our own. By sending our films abroad with their original sound tracks the peoples of the world familiarize themselves with the sound of spoken English. With the superimposed title in their own language, and with its translation into English just below it, they become familiar with the symbols of the English alphabet.

We produce many films that are purely national in character. Many of these do not lend themselves to translation. We receive foreign films, *Carnival in Flanders*, for instance. Had a literal translation into English been dubbed in, this film would have been censored out of existence. But by preserving the original sound track,

millions of people laughed and enjoyed themselves, reading the superimposed titles, and thus getting a more complete knowledge of what the action meant. Had there been French translations under the English titles, language students would have been still further aided. It works both ways. We can help to teach English to foreigners with the double title, as well as help ourselves to learn the language of foreign pictures.

All films, if they are well produced and directed, are entertainment. All films are propaganda for their place of origin. If we view a film with its original sound track, we are not as conscious of the differences in our modes of life and thinking, and we come away with a more kindly feeling. The same thing is true with our films reaching foreign lands. Speech stresses our differences, but pictures do not antagonize. With a translation dubbed in, people who look at life through differently colored spectacles get an entirely distorted view, as they have done in the past, of life as it is lived in these United States.

As far back as 1928 and 1929, the League of Nations was already concerned with the effect English and American films were having on the peoples of the Far East. The white race was losing prestige among the Indians and other Orientals, and according to the League reports, this resulted primarily from the sort of thing that was shown in our films.

Many people still do not comprehend the movies. To them the popularity of the neighborhood movie has no relation to the fundamental human need it serves. A few farsighted men, men like Mortimer Adler, Allardyce Nicoll, and others, realize that the film is the greatest of all cultural mediums and must be scientifically observed and evaluated, and that it is a powerful educational weapon. Many of us have failed to recognize that what the philosophers of all time have been searching for is at hand—a means of communication with all races, all nationalities, young and old. An international, universal basic language arrived with the motion picture. Here is a medium, call it cultural if you will, that can have a theater filled with people—no one of which speaks the language of any other—completely understanding the story which unfolds on the screen.

The beauty of teaching Basic English by the use of translated sub- or superimposed titles is that it is not obvious in intention. Such a method will arouse an interest in English. It will bring about the forming of adult classes in English, particularly in countries where English is taught in schools. And above all, it will prove an invaluable

able aid to the language teacher. It will add entertainment to the teaching of the auxiliary language. And Basic English is just that, an auxiliary language. It is said that there is no royal road to knowledge, but this will prove an entertaining road.

BOOK REVIEW

Correct Exposure in Photography. By WILLARD D. MORGAN AND HENRY M. LESTER. *Morgan & Lester* (New York), 1944, 124 pp. $9\frac{1}{4} \times 6$ in.

The subject of Morgan and Lester's most recent publication is the Weston Exposure Meter. The authors have assembled into one volume most of the material which is contained in the various pamphlets prepared by the manufacturer of the Weston Meter, and have supplemented this information with practical suggestions for using the meter in various specialized applications.

In general, the procedures outlined by the authors for obtaining correct exposure with the Weston Meter are sound and should be of considerable assistance to the conscientious photographer. The principal weakness of the book is in the authors' efforts to explain why it is advisable to use the meter as specified. At best their treatment of the problems of photographic tone reproduction is inadequate. Their conception of the relationship between scene brightnesses and film latitude is confused by their failure to appreciate the limitations imposed by the printing medium or the reversal process. Much of their concern over the importance of precisely correct negative exposure is of little consequence in view of the fact that it is the positive and not the negative which normally determines the subject brightness range which can be satisfactorily reproduced photographically.

Messrs. Morgan and Lester are at times ingenious, if not correct, in their analysis of the factors which determine exposure latitude. The mathematical procedure by which they demonstrate that the shorter latitude of color films may be attributed to the presence of 3 emulsion layers is unique, but without support in fact. They come to the conclusion that the range through which color processes, such as Kodachrome, will handle colors of varying brightness is only 1 to 4, and that, therefore, any scene having a brightness scale greater than this exceeds the "film range." If this were true, even the shortest scale scenes, which normally have a brightness range appreciably greater than 1 to 4, could not be reproduced satisfactorily in both highlights and shadows by a 3-emulsion layer color film. Experience has shown that scenes of this type are admirably reproduced in Kodachrome.

Where the authors have held more rigidly to the text of the manufacturer's booklet on the use of the Weston Meter and to the standard treatments of the exposure problem, there is little to criticize. The description of the various models of Weston Exposure Meters is complete, and the discussion of the theory and construction of the meters is good. The chapter devoted to the measurement of film speed describes the original Weston system which, contrary to the authors' statements, has not "become almost universally adopted in photography."

The chapter on film development and various statements throughout the book concerning the influence of development are perhaps the authors' most valuable

contribution. The amateur photographer may also profit from their suggestions for using the meter for special applications, such as high and low key portraiture, table-top photography, copying, and title making.

J. L. TUPPER
December 2, 1944

CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

The editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D. C., or from the New York Public Library, New York, N. Y., at prevailing rates.

American Cinematographer

25 (Sept., 1944), No. 9

A New Portable Processing Printing and Editing Kit (p. 295)

Art and Technique in Set Designing (p. 298)

E. CARRICK

Lighting Republican and Democratic Conventions (p. 306)

25 (Oct., 1944), No. 10

High-Efficiency Stereopticon Projector for Color Background Shots (p. 332)

F. EDOUARD

Francis Doublier, Cameraman Fifty Years Ago (p. 334)

I. BROWNING

Filming a Motion Picture in One Set (p. 336)

R. JOSEPH

British Kinematograph Society, Journal

7 (July-Sept., 1944), No. 3

High-Speed Cameras (p. 84)

E. D. EYLES

Heating and Ventilating of Kinemas (p. 92)

L. W. J. HENTON

Educational Screen

23 (Sept., 1944), No. 7

The Challenge of Television (p. 284)

J. FLORY

23 (Oct., 1944), No. 8

Post-War Planning for the Audio-Visual Program in St. Louis (p. 344)

D. BLACKWELL

Who Will Make Visual Aids in the Post-War Period? (p. 346)

D. C. ROGERS

Electronic Industries

3 (Nov., 1944), No. 11

Sound Amplification by Air Modulation (p. 84)

Electronic Color Television (p. 101)

International Projectionist**19** (Sept., 1944), No. 9

- The Design of Sub-Standard Sound Projectors (p. 7) H. CRICKS
Orthoscope Lenses New Projection Aid (p. 10)
Projectionists' Course on Basic Radio and Television (p.
12) M. BERINSKY
Television Today, Pt. XII—Color Television (p. 20) J. FRANK, JR.
19 (Oct., 1944), No. 10
Thomascolor: Four-Color Process for Motion Pictures
(p. 70)
Projectionists' Course on Basic Radio and Television (p.
10) M. BERINSKY
The Duplex Loudspeaker (p. 14) J. B. LANSING
Television Today, Pt. XIV (p. 22) J. FRANK, JR.

SOCIETY ANNOUNCEMENTS

ATLANTIC COAST SECTION MEETING

Paul Terry, originator and producer of Terrytoons, discussed "Animated Cartoons—Past, Present, and Future" before 150 members and guests of the Atlantic Coast Section of the SMPE at a meeting held on November 15. Mr. Terry is one of the pioneer producers of motion picture cartoons, having been in the field for over 30 years. He told of his early experiences as a newspaper cartoonist, and how an animated cartoon produced by Winsor McCay in 1914 inspired him and crystallized his decision to enter this field.

The animated cartoon has since come to occupy an important place in the motion picture industry. While consuming only about 7 min of screen time in the commercial theater, or approximately one per cent, these cartoons receive about 50 per cent of screen time in private homes. In conjunction with comic magazines and comic strips in newspapers, the animated cartoon in the home is developing children to follow progressive action, to study and appreciate drawings and color, and is building an audience for general motion picture entertainment.

Mr. Terry believes that the animated cartoon will predominate in the choice of entertainment utilized in television. Its brief running time and low cost compared with full-length feature pictures make it easily adaptable to the new medium.

The meeting, held in the Roof Garden of the Hotel Pennsylvania, New York, was opened with a showing of the motion picture, "The Birth of the B-29."

EMPLOYMENT SERVICE

POSITION OPEN

The following position of interest to SMPE members was available at JOURNAL press time. Applicants should apply *direct* to company at address given.

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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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No. 2

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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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No. 2

THE PH-346A RECORDING EQUIPMENT*

WESLEY C. MILLER**

Summary.—*Superportable double film recording equipment designed under the auspices of the Research Council of the Academy of Motion Picture Arts and Sciences, at the request of the Army Pictorial Service, to provide equipment not available to the Armed Forces through the normal supply channels, is described in the following paper.*

The equipment fills the immediate need for wartime purposes for completely portable, relatively high-quality field or studio work. Moreover, the practicability of extensions and adaptations to post-war requirements have been kept in mind so that its flexibility and value may later be enhanced by arranging it to handle more refined work if desired. It also will probably find a place in studio work when supply conditions are such as to make it commercially available.

The greatly increased motion picture production demands occasioned by the war found the armed services in the position of being unable to secure a completely portable 35-mm double film sound recording system from the usual supply sources. In July, 1942, the United States Army Pictorial Service of the Signal Corps, wishing to take advantage of the operating and design experience of the motion picture studios, requested the Research Council of the Academy of Motion Picture Arts and Sciences to undertake the design and construction of such equipment. A committee was set up under the Research Council organization with the writer as Chairman. However, as it subsequently turned out, virtually the entire conception and responsibility for the project remained with the writer as an individual. Fortunately, it was possible to undertake the work in the Metro-Goldwyn-Mayer Sound Department so that the advice and experience of many interested individuals became available.

* Presented Apr. 18, 1944, at the Technical Conference in New York.

** Sound Department, Metro-Goldwyn-Mayer Studios, Culver City, Calif.

The project was undertaken by the Research Council on its usual nonprofit basis, and the only engineering costs directly charged to the work were those relating to actual drafting and physical work.



FIG. 1. Field use of equipment.



FIG. 2. Equipment units.

The contractual relationships were subsequently modified so that the Stephens Manufacturing Company of Los Angeles became the prime manufacturing contractor, with the Research Council and the



FIG. 3. Front of recorder unit.



FIG. 4. Back of recorder unit.



FIG. 5. Film compartment and movement—35-mm.



FIG. 6. Back of recorder unit opened for inspection.

writer continuing in their responsibility for the design and for engineering supervision of the manufacture.

The primary need was for a limited number of units for immediate service by the Signal Corps. In the meantime, other branches of the Armed Forces have shown an interest in the potentialities of the equipment. Keeping in mind the wartime demand, every attempt has also been made to have the equipment capable of permanent use by planning later modification for even greater flexibility. At relatively slight cost and complication it can be adapted to record nearly any of the conventional types of sound track; it can be arranged for synchronous or interlock operation for stationary use, and at the same time retain its desirable portability features. Its



FIG. 7. Control panels.

post-war possibilities for commercial studio use have been apparent to studio technicians who have examined it.

The first 4 units are now in service and have been approved by the Army Pictorial Service. An example of its use in the field is shown in Fig. 1.

Portability and Quality Requirements.—The requirement was a film recording channel which would operate with or without a camera and which would be as small, compact, and light as practicable, and be capable of relatively high-quality work. Mechanical construction to withstand field operation, ease and reliability of operation by relatively inexperienced personnel, and provision for simple and adequate maintenance were also of importance.

The equipment was to be capable of use wherever the double system, that is, sound and picture made on separate machines, was

required. The first models were to be designed for use with the Mitchell NC type of 35-mm camera with, however, the expectation that later adaptations would be made to accommodate other types of cameras, either 16-mm or 35-mm. Thirty-five millimeter standards were specified for the sound recording with the added provision that 16-mm film should be accommodated if possible with, however, the provision that the 16-mm film and its sound track should conform to 35-mm, 90-ft per min standards so far as film travel and sound track width and location were concerned.

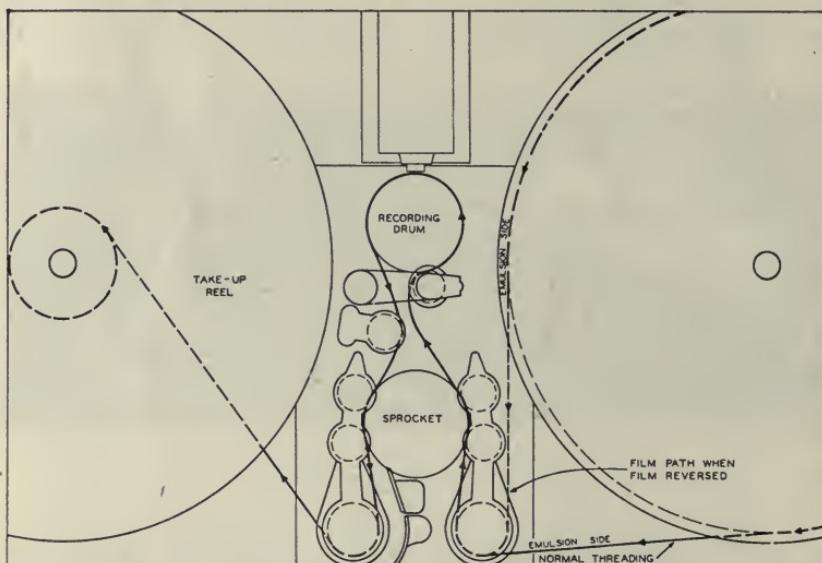


FIG. 8. Film threading guide.

For purposes of portability and film economy, this use of 16 mm can be of advantage without sacrificing the benefits of the 35-mm sound quality. However, the original requirement has since been changed, and the Army Pictorial Service requires only the 35-mm adaptation, although the 16-mm use may fill a need elsewhere.

Fig. 2 shows the complete equipment which consists of the following units:

- (1) Recorder unit, containing all of the operating parts of the complete recording channel, such as film drive, amplifier system, controls, *etc.*; weight 93 lb.
- (2) Accessory unit, which carries the various accessories required, such as

microphone, headphones, cables, spare parts, *etc.*; weight 60 lb with normal spares and accessories.

(3) Film unit, which carries the film supply and all accessories relating directly to the use and handling of film. It carries a maximum of 6000 ft of 35-mm film, or a somewhat greater amount of 16-mm film; weight, 40 lb complete with all usual accessories, but without film.

(4) Two storage battery units, which are the entire battery supply for the complete equipment, including the camera motor. Each is a 24-v, 45-amp hr battery, and weighs 87 lb. The units may be used separately or together.

(5) Camera motor unit, which consists of a carrying case and camera motor

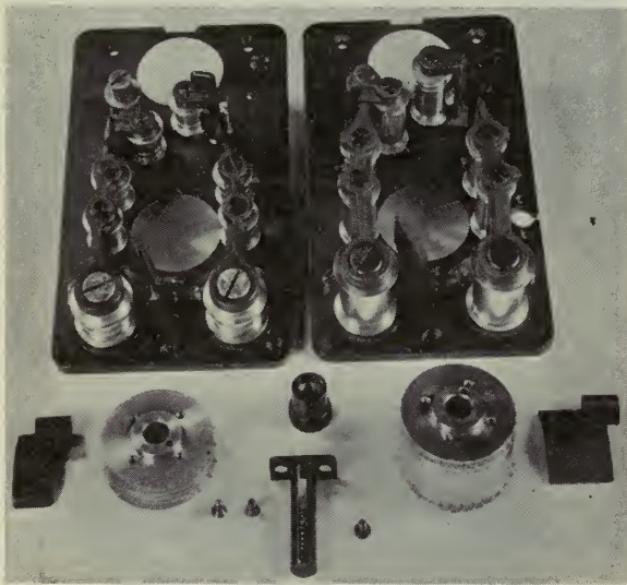


FIG. 9. Sixteen-millimeter and 35-mm adapter parts.

for the Mitchell NC-type camera. Total weight of motor and carrying case is $24\frac{3}{4}$ lb.

Thus, the complete equipment weighs approximately 392 lb without film. For particular uses where weight must be further reduced, less film may be carried and certain of the accessory equipment temporarily eliminated. The bare minimum weight for sound recording only, using one 1000-ft roll of film, is slightly under 200 lb.

The recorder unit, accessory unit, and film unit are all of the same outside dimensions, namely, $10 \times 26 \times 13$ in., and the storage batteries are considerably smaller. Each unit can quite readily be carried by one man, or a small crew can manually transport the



FIG. 10. Film reel loading, step 1.



FIG. 11. Film reel loading, step 2.



FIG. 12. Film reel loading, step 3.



FIG. 13. Film reel loading, step 4.

entire equipment over considerable distances. For use on ship-board, airplanes, or where space is at a premium and handling is difficult the package sizes are very useful.

In spite of these reductions in weight and size, the sound quality obtainable with the equipment very closely approximates the general average of commercial sound recording. The potential use for the equipment was primarily in the recording of dialogue and sound effects. However, a music equalizer is supplied to augment the low-frequency end although the speed control when operating from a battery source will not maintain the flutter at the low value normally required for very high-grade musical recordings, a compromise which was deliberate because of the portability requirements. Picture quality and results are entirely dependent upon the camera and its operation, as the only purpose which the recording equipment serves in this connection is to provide a means of driving the camera in synchronism with the recorder. In this respect the drive is identical with that provided for studio location purposes.

Recorder Unit.—The recorder unit is the heart of the equipment. It contains the entire recording channel except for microphones, headphones, and battery.

The film compartment in the front houses the film movement and the galvanometer, and also serves as a film magazine during operation. A rear compartment, readily accessible by opening the rear cover, houses the driving motor, amplifier, and all of the miscellaneous equipment required to complete the recording channel. Control panels are located in the top of the box with all of the voice controls, such as the mixer, volume indicator, meter switches, etc., at the operator's left, and a power panel controlling the motor systems at the right. The case is constructed in such a manner as to make all of the various elements quickly and easily accessible while at the same time being of sufficiently sturdy construction to withstand the kind of treatment which it is apt to get under field conditions. The outer housing is made of weather-proof plywood with a sheet metal outer layer. This is braced internally with angle sections which also form the mounting for various parts of the equipment. Figs. 3, 4, 5, and 6 show various views of the recorder unit.

Fig. 7 shows the control panels in the top of the recorder unit box. When not in use these control panels are covered by doors which swing out of the way to make the control panels available for operation. A panel separates the film compartment from the rear com-

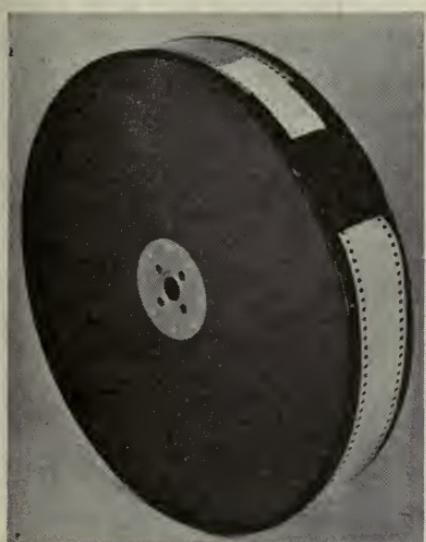


FIG. 14. Loaded film reel ready for use.



FIG. 15. Loading bag in use.

partment and also serves as a backbone to stiffen the box construction. The various elements which make up the film drive are mounted on this panel.

Film Drive.—The film drive, as shown in Figs. 5 and 8, employs a single sprocket which acts as a combined pull-down and holdback sprocket and a recording drum, which is controlled by a flywheel system of the rotary stabilizer type. The take-up clutch is mounted on the sprocket shaft and has provision for adjustment from the film compartment. The clutch drives the take-up spindle through a silent chain.

All of the various rollers associated with the film drive are mounted on a removable plate as seen in Fig. 9. To use either 35-mm or 16-mm film the proper plate is installed and the corresponding sprocket is placed on the sprocket shaft.

Film Handling.—The conventional external magazine is eliminated in this design and a form of daylight loading technique has been adopted. Referring to Figs. 10, 11, 12, 13, and 14, film as received from the supplier is loaded in the darkroom onto a reel which is composed of 2 flanges screwed on either end

of a hub. A cover is then placed over the loaded reel with 3 or 4 ft of threading leader brought out through a slot in the cover. In this condition the reel of film may be exposed indefinitely to daylight. To load a reel of film into the recorder, a film reel with its cover in position is placed on the feed spindle and all of the threading operations are carried on with the reel cover in position. When the threading is complete the reel cover is removed and the film compartment door is closed. Unloading is done in the reverse fashion, that is, the film compartment door is opened and a reel cover placed in position on the take-up reel. A loading bag,

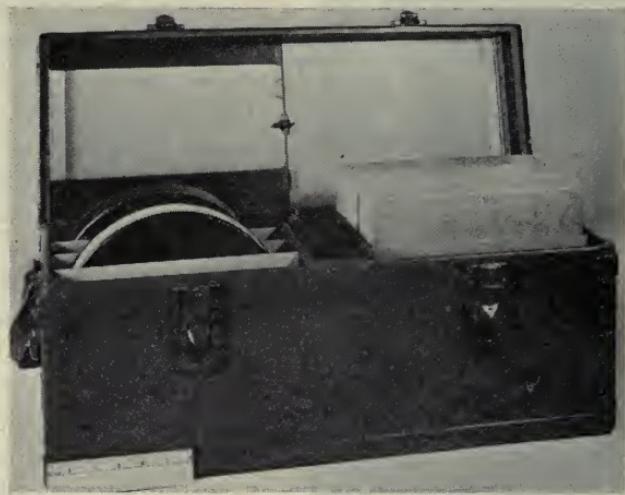


FIG. 16. Film carrying unit.

Fig. 15, is supplied which covers the entire recorder during the reel cover removal to prevent light striking the film.

It was the original intention that gray antihalation film stock should be used. In this case, the use of the loading bag was unnecessary except under extreme light conditions. However, clear base film is now a standard in the services so that the use of the loading bag is specified for all loading and unloading operations.

The film reel parts, loaded reels, film covers, film supply, and loading bag are carried in the film unit, Fig. 16. The use of this form of film reel and the elimination of the conventional magazine make quite a saving in weight and size of equipment and offer no

more difficulty in operation than in the use of 16-mm or Eyemo camera equipment.

Motor Drive System.—Both recorder and camera driving motors are a special design of the conventional d-c interlock type, operating from 24-v d-c derived from the storage battery unit, with a 3-phase, 24-cycle, 110-v interlock supply derived from auxiliary windings in each motor. The 4-pole recorder motor, which is an integral part of the recorder unit, operates at 1440 rpm. The 2-pole camera motor operates at 2880 rpm. Field rheostats controlling the speeds of the 2 motors are on the power panel in the recorder unit. Correct motor speed is indicated by a vibrating reed type of tachometer mounted close to the volume indicator meter for the operator's ease in referring to it. Both motors are designed to operate satisfactorily over a voltage range from 18 to 25 v to take care of variations in storage battery conditions.

The camera motor for the Mitchell NC camera is shown in Figs. 17 and 18. In appearance the motor housing is similar to that of the conventional motor adapter for this type of camera.

Arrangements to interlock this equipment with any auxiliary equipment, or to operate it synchronously from an alternating current source, are quite practicable through the medium of auxiliary distributors or a synchronously driven 24-cycle frequency changer.



FIG. 17. Camera motor in housing for Mitchell NC camera.

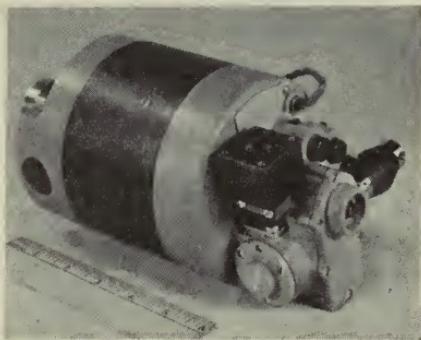


FIG. 18. Camera motor.

This could be of value in a semipermanent stationary application.

Sound Track.—The equipment as supplied records unilateral variable-area sound track conforming to the nominal 35-mm standards with respect to track dimensions and location on the film. As previously suggested later adaptations can be made to produce other types of track as desired. When 35-mm film is used the track is the same as any 35-mm recording using track of this kind. When 16-mm film is used (see Fig. 19) the track dimensions and location

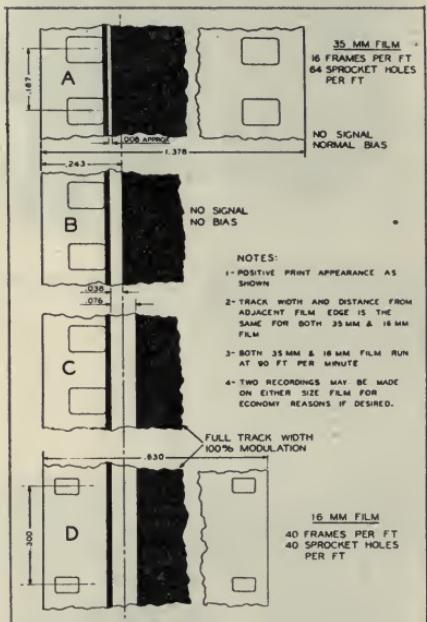
with respect to the adjacent film edge remain the same as for 35-mm film. This choice for the 16-mm film was made to permit the use of 16-mm film on 35-mm reproducing equipment without changing film location, optical systems, etc. It is relatively simple to replace sprockets and rollers in most 35-mm reproducing heads with 16-mm sprockets and rollers having the same approximate diameter dimensions, thus permitting the machine to run the 16-mm film at 90 ft a min very satisfactorily.

It is the expectation that practically all material re-

FIG. 19. Sound track dimensions—16- and 35-mm film.

corded with this equipment will normally be rerecorded. In view of this it makes little difference whether the original film is wide or narrow, except for possible editorial difficulties, if the original sound quality is that obtainable with wide film standards.

Modulator.—The modulator now used in the equipment is the E. M. Berndt Corporation Auricon-type galvanometer mounted in a special housing as shown in Fig. 20. Noise reduction amounting to 6 db is attained by a d-c bias of the galvanometer movement. This galvanometer was adopted because of its generally rugged construction and simplicity of operation. Arrangements are made for



focusing and lateral adjustment of the light beam without requiring special and complicated optical test equipment. These adjustments may be very readily made in the field in case galvanometer replacement is required.

Space provision is made for the use of other modulator types as future applications of the equipment would probably require studio-type modulators. The general design is sufficiently flexible to permit such adaptations to be made.

Amplifier System.—The amplifier system is completely contained in one unit which is shown in Figs. 21 and 22. This unit is mounted in the recorder unit in such a manner that it may be readily removed by removing 4 thumbscrews and disconnecting a plug and jack. The unit is suspended on rubber shock absorbers which form a part of the slide mounts which are released when the thumbscrews are removed. This removable feature is very important for field maintenance purposes. The amplifier is necessarily complex in its operation, but normally the man in the field is not supposed to go beyond changing tubes if trouble develops. If

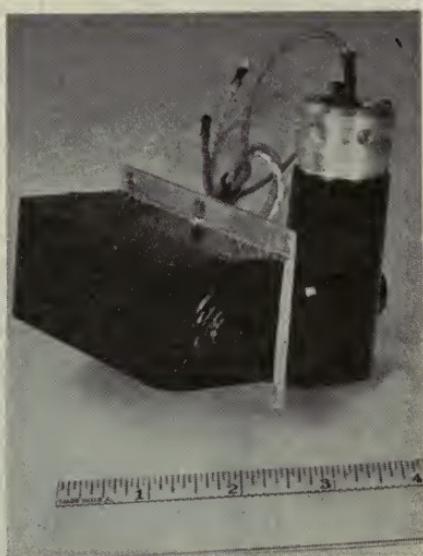


FIG. 20. Auricon galvanometer unit.

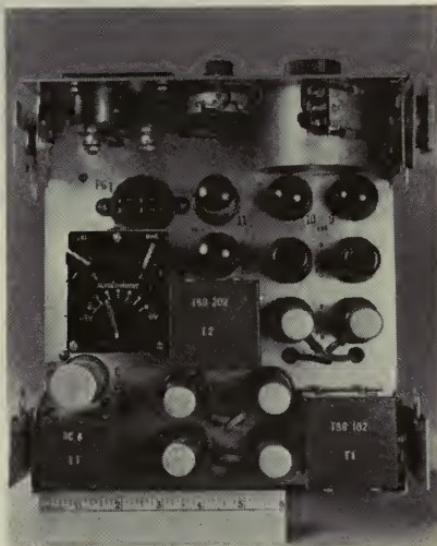


FIG. 21. Front of amplifier.

this method of correction is insufficient, he can remove the entire amplifier unit and replace it with another.

The amplifier assembly contains a mixer position for one microphone, auxiliary gain controls, and a meter which is used interchangeably for checking the various circuit conditions, the recording exciting lamp current, and as a volume indicator or as a limiter in-

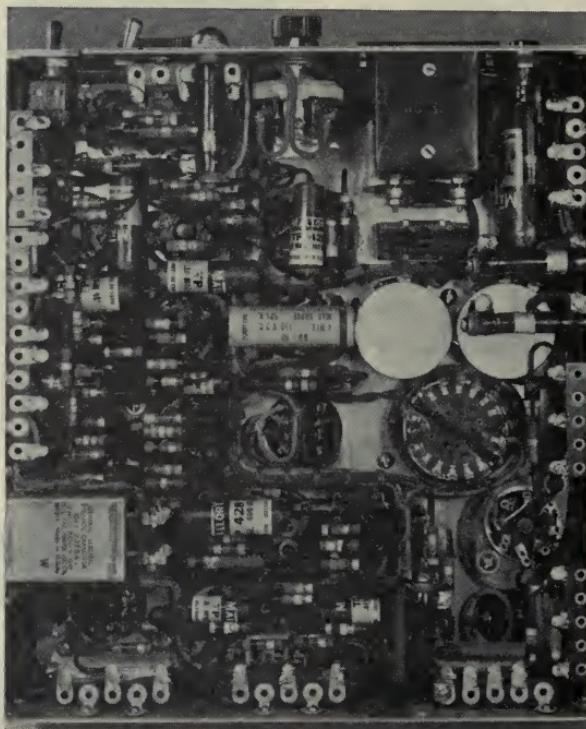


FIG. 22. Back of amplifier.

indicator. Switches to connect the meter into the various parts of the circuit for its several uses are on the panel and on a subpanel accessible through a rear door. The normal maximum gain for the amplifier is 110 db with an additional 15 db of gain which may be used if necessary, but with a corresponding increase in noise level. This additional 15 db is used without the increase in noise when the music equalizer is connected for use. The equalizer switch is also mounted on the rear subpanel.

Limiting action is provided in the amplifier corresponding to the type of limiting in normal use in studio recording. The limiting operation is a change in gain which occurs very rapidly (of the order of $1/10,000$ sec or faster) on excessive peaks and restores much more slowly (about $2/10$ sec). It is set to operate very slightly above 100 per cent galvanometer modulation level, and its general characteristics are shown in Fig. 23. The limiting feature is very valuable for consistent operation, as it controls maximum level, protects the

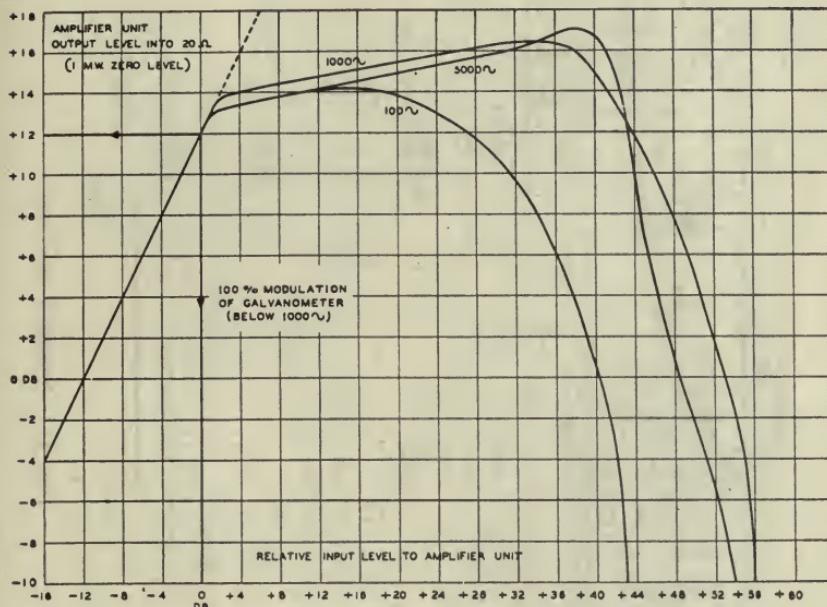


FIG. 23. Limiter operating characteristics.

modulator and, in general, assures the highest practicable recording level on the film. The meter is arranged to indicate limiting action or, if desired, it may be used as the conventional volume indicator.

The amplifier circuit is shown schematically in Fig. 24, and the connection of the amplifier to the remaining equipment in the recording unit is shown in Fig. 25. The over-all recording characteristics of the equipment are indicated in Fig. 26.

Microphones.—Provision is made for the normal use of one microphone only. If, however, 2 microphones are required, an extension mixer (see Fig. 27) is connected in place of the single micro-

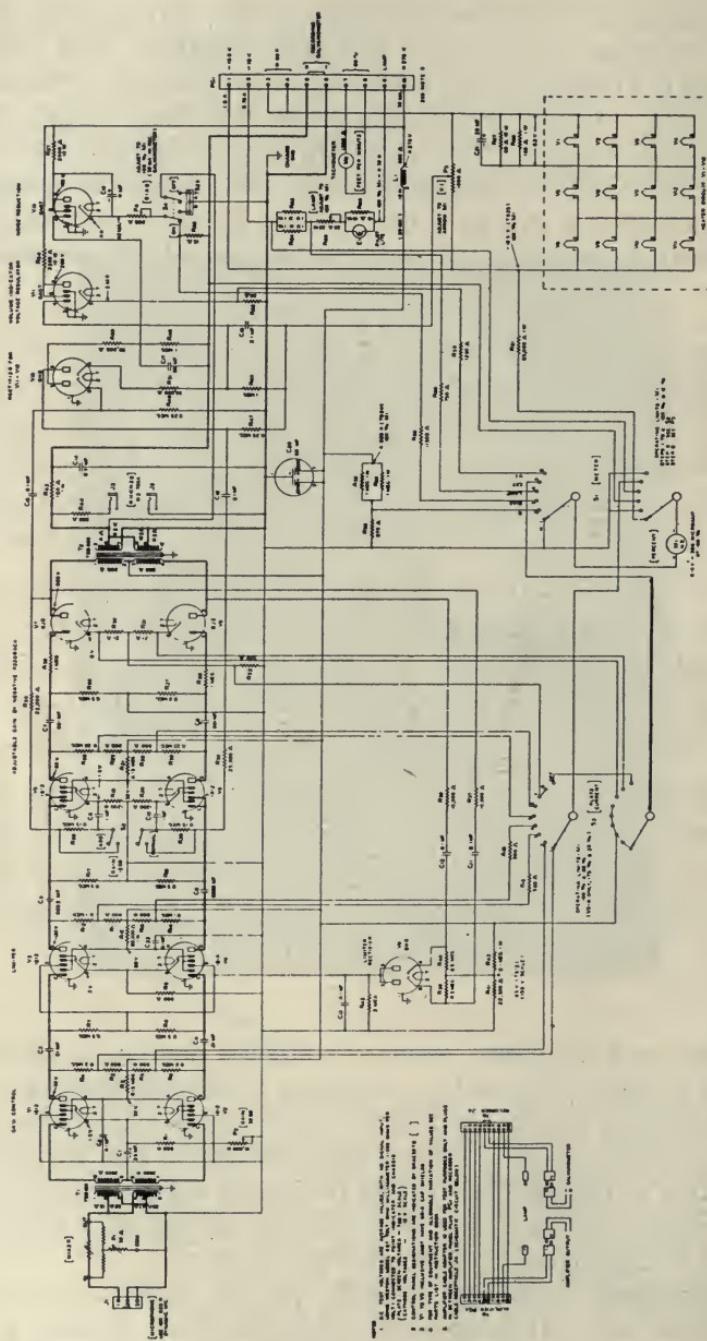


FIG. 24. Amplifier schematic.

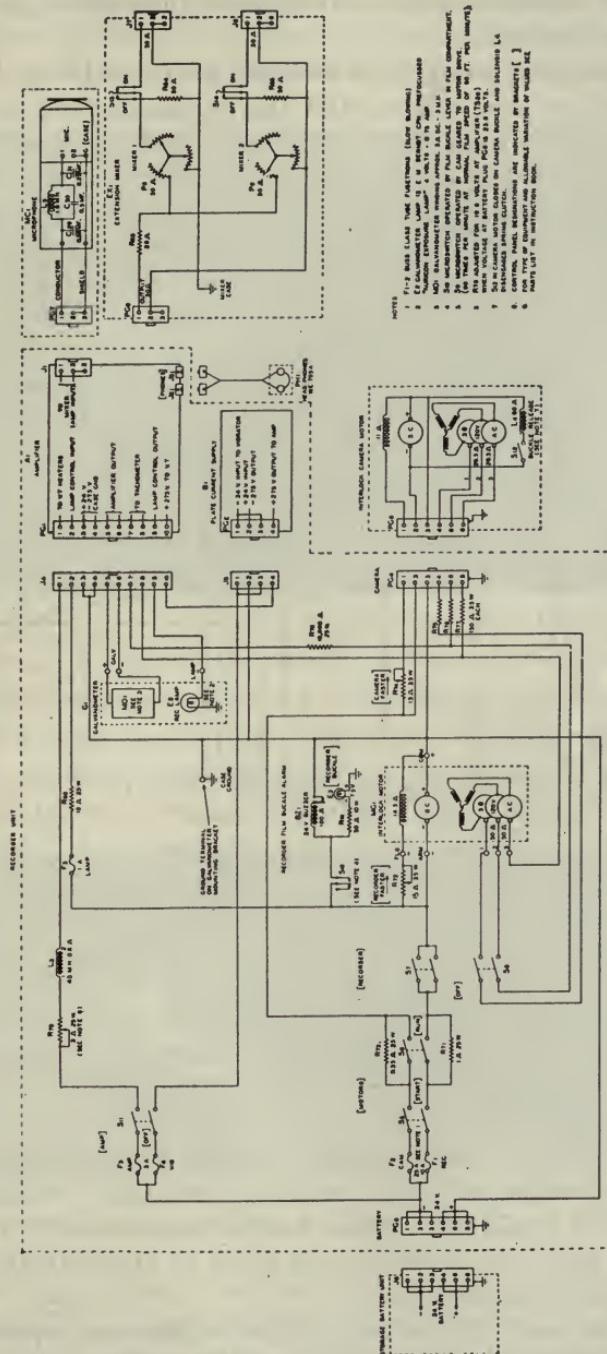


FIG. 25. General schematic showing interconnection of units.

phone, and 2 microphones may be connected through and controlled by the extension mixer.

The equipment was originally designed for use with the Western Electric 618-type microphone, and this is specified for use when available. Owing to wartime production conditions, neither this microphone nor the 630 type was obtainable, and the Western Electric 633 microphone was substituted. Because of the excessive high-frequency response of the latter microphone, a low-pass filter became necessary. In order to leave the amplifier circuit normal so

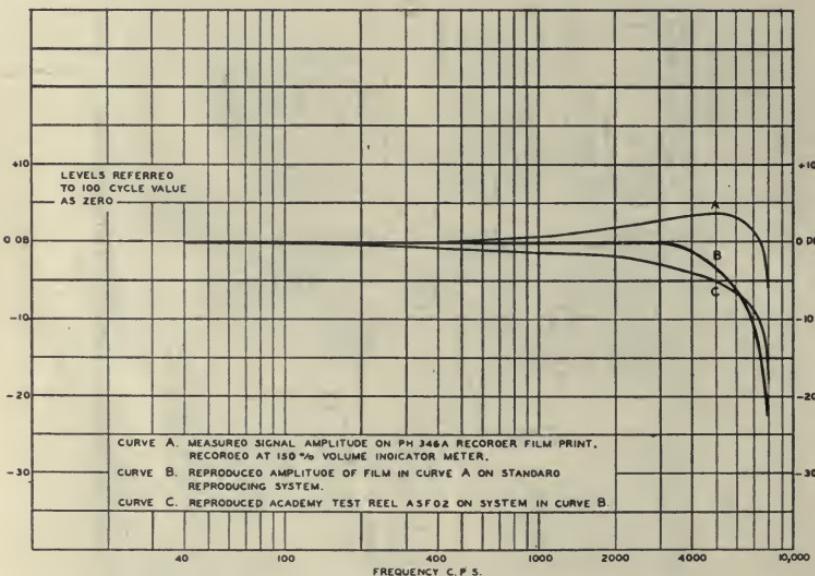


FIG. 26. Operating frequency characteristics.

that other types of microphones could later be used, the low-pass filter for the 633-type microphone was mounted as an extension to the normal microphone housing. The resulting combination microphone and filter is shown in Fig. 28.

Training Manual.—The equipment is such that with the barest operating knowledge of sound recording reasonably consistent results should be attainable. Basic instruction and meter readings to check the operating conditions are given on an instruction plate on the cover of the mixer panel.

In addition a very detailed instruction booklet was prepared from which a complete working knowledge can be obtained.

The equipment as now in service appears to fill a definite need. It is not to be thought of as competing with the heavier truck-mounted or stationary equipment although, as a matter of fact, its



FIG. 27. Recorder unit with extension mixer in place for using 2 microphones.

performance will compare very well with it, and because of its portability it can often do a job which could not otherwise be accomplished. As previously suggested, it lends itself to adaptations which will permit its usefulness in more highly refined work during

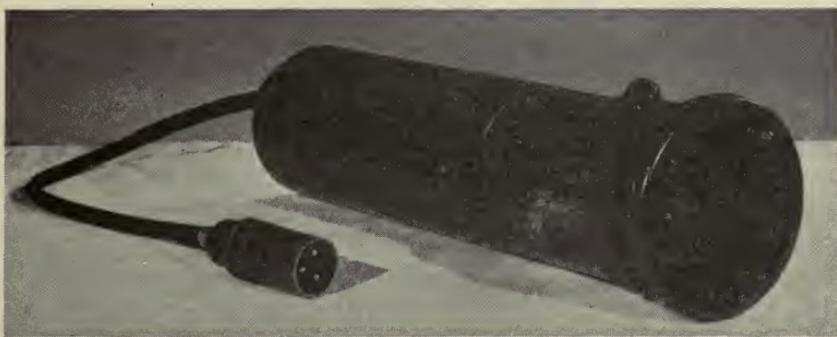


FIG. 28. Western Electric 633 microphone with low-pass filter attached.

post-war applications, a fact which is of distinct economic importance. It also appears probable that it will find a use in studio work when supply conditions once more become more nearly normal.

Acknowledgment.—The Research Council, the writer, and those who have helped him are very happy to have been able to contribute this design to the Armed Forces and to know that it has been of some value in the war effort. Sincere appreciation for their interest and contributions is due to Douglas Shearer, G. M. Sprague, Carlos Rivas, O. L. Dupy, Wm. S. Haddock, Elmer Woods, and B. B. Korn of the Metro-Goldwyn-Mayer Sound Department, to Robert L. Stephens of the Stephens Manufacturing Company, and to William F. Kelley, Manager of the Research Council, Academy of Motion Picture Arts and Sciences. Appreciation is also due to Lieutenant Howard T. Souther, Signal Corps, who very graciously offered to present this paper at the Society of Motion Picture Engineers' Convention. This is of particular value because of Lieutenant Souther's complete familiarity with the equipment acquired during the approval tests by the Pictorial Engineering and Research Laboratory Division of the Army Pictorial Service.

SOME TURBULATION CHARACTERISTICS OF THE NEW TWENTIETH CENTURY-FOX DEVELOPING MACHINE*

M. S. LESHING AND T. M. INGMAN**

Summary.—*It was necessary to have a clear idea about a simple and practical means of measuring developing solution turbulation as an aid to the design and construction of a new developing machine at the Twentieth Century-Fox laboratory. Such a means was evolved by engineers at this laboratory, and it is the purpose of this paper to describe the method of turbulation measurement, and the results of some preliminary tests made with both the new and old developing machines.*

The authors of this presentation hesitate to dignify it with the name "paper." It is much closer to being notes from the notebook of a practical laboratory man. It is intended only to call the attention of laboratory personnel to the necessity of a study of processing of film, and if the presented curves and thoughts will be in any way helpful, it is all the authors can hope for.

There were 2 reasons why we kept thinking about the necessity of acquiring new developing machines. The main reason was that our old Spoor-Thompson's were of an inflexible type. The speed of this developing machine effects the turbulation of the developing solution, and there are very definite limits beyond which we could not go in prolonging the time of development. We could not properly handle extra fast stocks, because they demanded longer development and by slowing up the machines to prolong the development, we also slowed up the rate of flow of our developing solution. As you can readily see, we "robbed Peter to pay Paul."

Besides this main reason, there was another, not less important. Our machines have been in continuous usage for the last 14 years, and we had no chance for any overhauling job, which the machines demanded.

* Presented Apr. 17, 1944, at the Technical Conference in Hollywood.

** Twentieth Century-Fox Film Corp., Beverly Hills, Calif.

In looking over the market for developing machines, we found there were not any to answer our requirements. The only machine which we thought was worth while looking at, was the developing machine at the Eastman Kodak Research Laboratory in Rochester, New York. Some tests were made on that machine, and as a result of the tests we decided to build the machines on the same principle as the so-called "Capstaff" machine in Rochester.

The main requisite in a developing machine, from our point of view, was the turbulation which would allow the processing of film, especially the making of dups, without any appreciable amount of directional effect. We would like to show a small reel of 35-mm film to demonstrate in a visual way the effects of turbulation on directional effect. This demonstration is fully in agreement with the statement made by Dr. E. M. Honan, Engineering Manager of

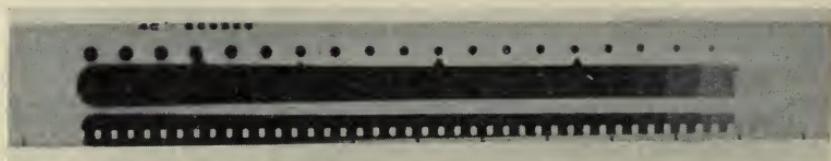


FIG. 1.

Electrical Research Products (who investigated the 96-cycle effect on film processed by us), that "the 96-cycle modulation is several db lower in Machine No. 6 than in Machine No. 2." Machine No. 6 is our new machine, and No. 2 is one of the old ones.

In the design and construction of the new Twentieth Century-Fox developing machine it was necessary to obtain a simple and practical means of measuring developing solution turbulation. Such a means was evolved by engineers at this laboratory.

During the process of actual development of motion picture photographic emulsions the by-products of the development reaction, especially the released bromide ions, accumulate at or near the film surface and exert a retarding action on the rate of development. Since the quantity of the by-products which accumulate at the film surface is a function of the area of the photographic exposure being developed, it follows that the retardation effect is also a function of the area exposure being developed. This phenomenon is demonstrated in the accompanying figures. It will be noted in Fig. 1 that

a regular H and D IIb sensitometric exposure has been developed in the center of the gamma strip. Each of the 21 exposure steps has an area of 0.16 sq in. Situated opposite each of the 21 steps near the perforations is a circular spot density which is the result of development of exactly the same exposure which was given the regular IIb sensitometric exposed areas. The area of this spot is 0.008 sq in., which is one-twentieth of the area of the adjacent square step exposures.

It is possible to obtain density measurements from the developed spot areas from which sensitometric curves can be derived in the

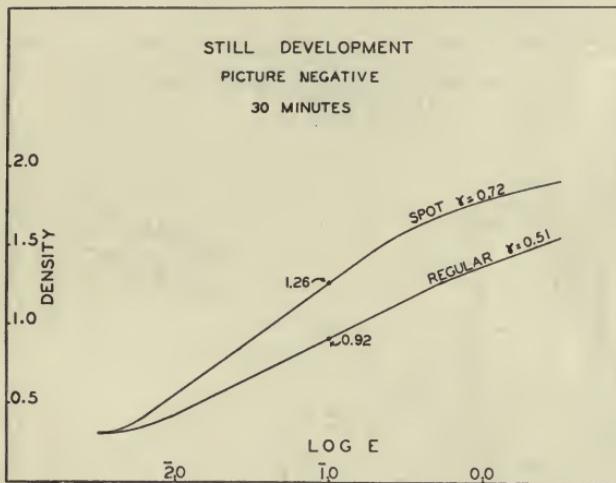


FIG. 2.

conventional manner. In Fig. 2 the H and D sensitometric curves are shown which were derived from both the regular IIb sensitometric exposures and the spot exposures on picture negative film with no developer agitation. The 2 plotted curves will be observed to differ vastly in both densities for any given exposure step as well as gamma. It will be noted that the higher densities and gamma value are obtained from the spot exposures.

The development rate of the regular square step exposure areas has been retarded owing to the accumulation of by-products of the development reaction. At the smaller spot exposure areas where only one-twentieth of the by-products of development was released from each step and where the distance between steps was relatively

great, very little retardation of development occurred *even though there was no agitation during development.*

The picture negative developer at the Twentieth Century-Fox Laboratory is a comparatively weak developer. The actual chemical concentrations which were derived from a chemical analysis of the developer are as follows:

Elon	0.4 gm
Hydroquinone	0.3 gm
Sodium Sulfite	75.0 gm
Potassium Bromide	0.33 gm
Water to make	1.0 liter
pH	8.90

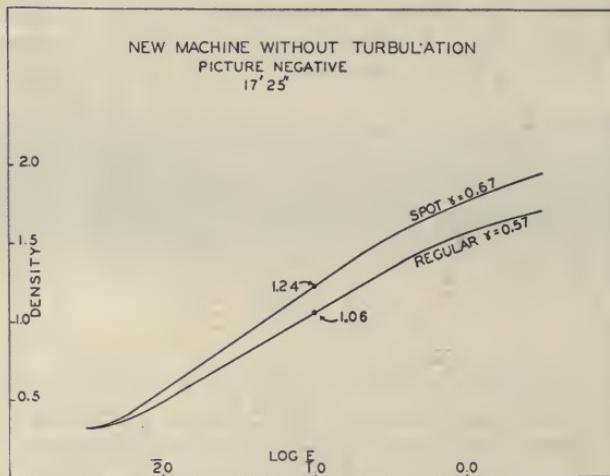


FIG. 3.

In the new machine under high turbulation it is necessary to use a developer with low chemical concentrations in order to maintain a desired time of development.

When this formula is used in combination with high turbulation conditions where the bromide ions and other by-products of the developer reaction cannot accumulate, a normal time of development of approximately 10 min and 30 sec is encountered. However, this developer is inherently sensitive to the retarding effect of bromide ions and other developer reaction by-products. In Fig. 2 it was necessary to develop 30 min in order to obtain a regular gamma of 0.51 without developer agitation.

If agitation is applied at or near the film surface so that a condition of turbulence is produced during the development of a photographic emulsion, the accumulation of the by-products of development is disrupted and fresh developer is continuously brought to that area on the film to replace exhausted developer. The simple movement of the motion picture negative film through a developing machine at a normal speed of 100 ft per min will produce a small amount of solution agitation at the surface of the film. The effect of this agitation is shown in Fig. 3 where sensitometric curves derived from the regular and spot sensitometric exposures are recorded. The time of development was 17 min and 25 sec.

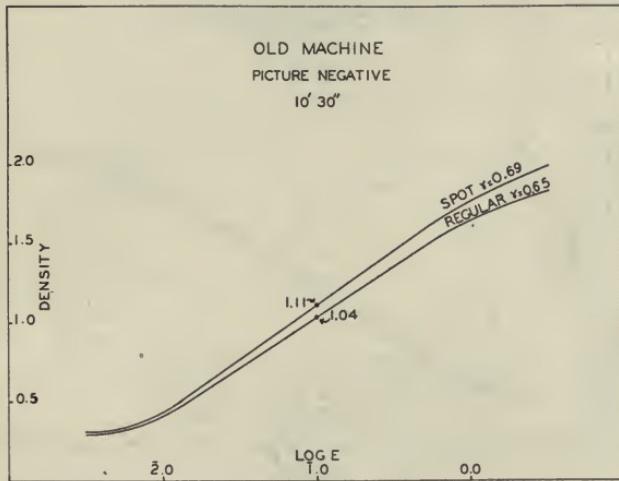


FIG. 4.

The difference between the densities of the spot exposures and the regular sensitometric exposures was considerably diminished by the agitation resulting from the simple movement of the film through the developing machine. Actually the difference between the 11th step exposures was 0.18, which is considerably less than the 0.34 value existing between the 11th step under conditions of still development. In this manner it is possible to evaluate quantitatively the photographic effect of turbulation applied to a motion picture photographic film during development by measuring the density differences between the spot exposures and the regular IIb sensitometric exposures.

In Fig. 4 sensitometric curves are shown which were derived from plotting the regular and spot densities obtained on picture negative

film after development in the old-type machine previously in use. This machine utilized the cascade system of turbulation whereby the developer flows from headers at the top of each rack. It will be observed that the difference between the 2 curves at the 11th step was 0.07; thus there is still some retardation of development of the regular IIb sensitometric exposures with this type of agitation. It was the aim of the Twentieth Century-Fox Laboratory engineers, in designing the new machine, to improve the degree of turbulation so that these 2 curves would approach as nearly as possible the same density values on all 21 of the regular IIb sensitometric steps.

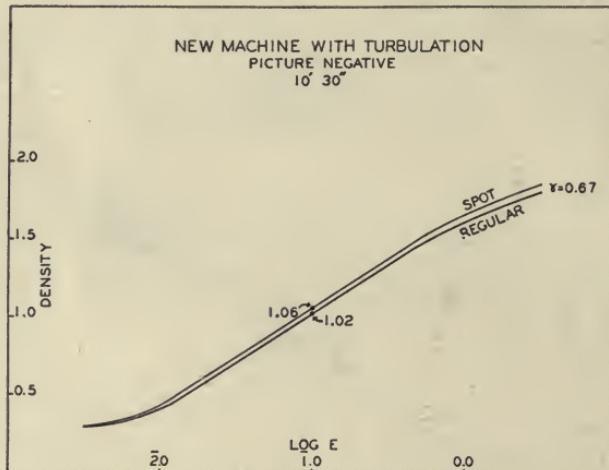


FIG. 5.

In Fig. 5 the sensitometric curves are shown which were derived from development in the new machine. It will be observed that the gamma obtained from both curves was 0.67. However, there was a small density difference of 0.04 at the 11th step. This would indicate that even the high degree of turbulation present in the new machine is not sufficient to prevent some retardation effect owing to the released by-products of development during the developing process of a regular H and D sensitometric exposure, but conditions of turbulation in the new machine do produce an improvement of approximately 50 per cent over the old machine.

In Fig. 6 the results of a special test conducted in this laboratory with the new machine are presented in graphical form. This test was made to determine the directional effect which would result from ap-

plication of turbulation in the new machine for varied times of turbulation, developing time being kept constant. This test was performed by making sensitometric exposures through the special Twentieth Century-Fox sensitometer template and spliced in at carefully measured intervals on a 1100-ft roll of leader. The footage intervals between gamma strips were equal to the footage capacity of a rack in the developing machine.

As a result, when the strips were developed in a normal manner in the new developing machine with regular turbulation, at the time that the first sensitometric strip emerged from the last rack of the

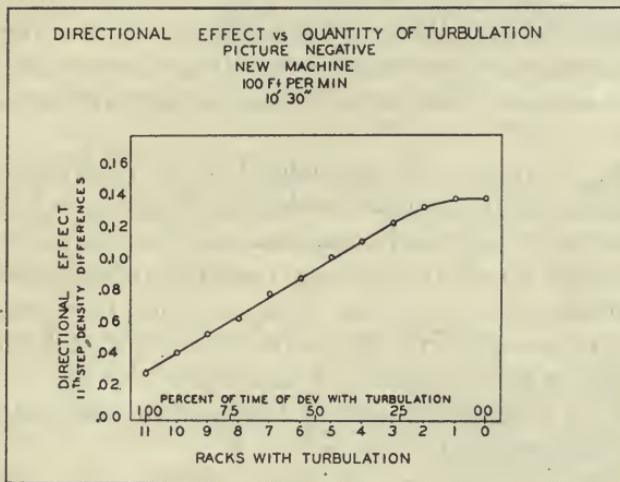


FIG. 6.

developer, the turbulation system was completely shut off, so that the last exposure on the roll, which at that same moment entered the first rack of the developer tank, received no turbulation during subsequent development. Each preceding sensitometric exposure received turbulation for a percentage of time of development depending upon its position in the machine at the time the turbulation was turned off. The resulting photographic sensitometric densities were plotted in the usual manner, and the difference between the spot and the regular 11th step densities was plotted as a function of percentage of time of development with turbulation.

It will be noted that the last strip to go through the developing machine, which received no turbulation whatsoever, yielded a density difference of 0.14. The next to the last strip also gave a density

difference of 0.14 even though it received turbulation while on the first rack which amounted to 10 per cent of the total developing time. Thus the effect of turbulation for the first 10 per cent of the time of development is negligible because apparently that much time is required for the reaction by-products to begin to accumulate. Beginning with the third strip from the end of the test each succeeding strip was found to possess smaller increments of density differences between the spot and regular 11th step exposures owing to the added percentage of time of development during which the turbulation jets were in action. The effect was linear, so that a 10 per cent increase in turbulation time resulted in a decrease of approximately 0.01 in the density difference between the spot and regular densities of the 11th step. With the turbulation jets turned on for 100 per cent of the time of development, a density difference of as low as only 0.03 was obtained on this test.

From the above test it is concluded that the current conditions of turbulation in use in the new developing machine are a decided improvement over the old-type machine and, from a practical standpoint, approach closely the optimum conditions of agitation.

The authors wish to express their gratitude to members of the Hollywood technical service staff of the Eastman Kodak Company for their assistance in preparation of this paper, and also to Dr. J. G. Frayne of the Electrical Research Products for assistance given in producing measurements.

REFERENCE

- LESHING, M., INGMAN, T. M., AND PIER, K.: "Reduction of Development Sprocket-Hole Modulation," *J. Soc. Mot. Pict. Eng.*, XXXVI (May, 1941), p. 480.

**STATEMENT OF THE SMPE ON ALLOCATION OF
FREQUENCIES IN THE RADIO SPECTRUM
FROM 10 KILOCYCLES TO 30,000,000
KILOCYCLES FOR THEATER
TELEVISION SERVICE***

Ed. Note.—When the Television Committee of the Society of Motion Picture Engineers, at its meeting on Sept. 18, 1944, studied the recommendations of the Radio Technical Planning Board on frequency allocations for experimental television, it was considered that these recommendations did not explicitly incorporate the needs of the motion picture industry. Thus it was decided that the Committee should take steps to insure adequate protection of the future requirements of theater television by making specific requests for the necessary channels at the Federal Communications Commission hearings in October, 1944.

Accordingly Paul J. Larsen, with Earl I. Sponable as Alternate, was delegated by the Committee to present the frequency allocation needs of theater television before the Commission. The text of the statement, with exhibits and figures accepted by the FCC, is reprinted here.

Mr. Chairman, Members of the Commission:

My name is Paul J. Larsen. I am a radio engineer associated with The Johns Hopkins University, Applied Physics Laboratory in war activities for the Office of Scientific Research and Development. I appear before the Commission today as the representative of the Society of Motion Picture Engineers to present their recommendations for frequency allocation requirements for Theater Television in behalf of the engineers of the Motion Picture Industry.

The Society of Motion Picture Engineers is composed of engineers of every group interested and active in the furtherance of the engineering perfection of motion pictures as presented to the public. This art of motion pictures encompasses all engineering phases relating to visual and aural presentations, whether on film or by other means such as television. The Motion Picture Industry relies upon the engineering guidance of the Society of Motion Picture Engineers in standardization of their products, equipment, and certain of their operating practices.

* Presented before the Federal Communications Commission (Docket No. 6651) by Paul J. Larsen, SMPE Representative, on Oct. 27, 1944. (Statement, exhibits, and figures bear FCC Exhibit No. 431.)

The duty of the American Motion Picture Industry is to serve the nation both in war and in peace, by a continued flow of high-quality entertainment and news, both visual and aural, to the theaters of the United States and to our military personnel in this country and in the field. Such a flow of entertainment entails all of the branches of the industry: production, distribution, and exhibition.

The production branch is comprised of approximately 172 producing companies with 22 major studios, of which the recognized majors are:

Metro-Goldwyn-Mayer
Twentieth Century-Fox Film Corporation
Paramount Pictures, Inc.
RKO Radio Pictures, Inc.
Warner Bros. Pictures, Inc.
Universal Pictures Company, Inc.
Columbia Pictures Corporation
Republic Pictures Corporation
Monogram Pictures
United Artists Corporation
Producers Releasing Corporation

The distributing branch consists of approximately 11 companies with 341 distributing offices in the United States.

The exhibiting branch, the theater, consists of over 5000 circuit or independent managements. Over 20,281 theaters are spread throughout the nation in over 8488 towns and cities. These theaters comprise a total of 11,719,101 seats. The estimated average weekly attendance exceeds 85,000,000.

The Motion Picture Industry employs regularly 193,600 persons in these three branches of the industry. Directly and indirectly it stimulates and promotes many other industries where post-war employment increases are needed and possible.

In respect to the income of the Motion Picture Industry, a comparison between the yearly gross income and taxes of the Motion Picture Industry and that of the Broadcast Industry is of interest. This comparison in round figures is based upon information obtained from the Department of Commerce, the Statistical Branch of the Federal Communications Commission, and the Broadcasting Yearbook, and are as follows:

	Motion Picture Industry	Broadcast Industry
Estimated Gross Income:	\$1,600,000,000	\$280,000,000
Amusement Taxes Direct to U. S.		
Treasury:	260,000,000	.....
Estimated State and Local Taxes:	300,000,000	20,000,000

The above figures of taxation do not include Federal Corporate and Private, Income and Excess Profit taxes.

The American Motion Picture Industry, in less than fifty years, has grown to be one of the major industries in the United States and is recognized throughout the world as the leader in the initiation and carrying out of all new means to present to the public improved visual and aural presentations. It is the eyes and ears of the world, bringing to every corner of the world a new understanding, a new concept and a new drive, that a better way of living may constantly be achieved. It aids public morale, relieves the strain of fatigue, and brings a vast store of enjoyment to untold millions.

The industry has at all times kept pace with developments, constantly utilizing and improving them with energetic and devoted effort to produce better and better motion pictures. During its early history presentations to the public were only visual in black and white, then in the late '20's sound was added and for the first time in the history of mankind there came into being a medium of expression both aural and visual. During the early '30's perfected color was added to this new medium of expression, increasing naturalness of the presentation and making it possible to present visual and aural expressions in all their splendor. During the present war motion pictures have proved to be indispensable for training by our services, and to the morale, the comfort, and the contentment of our fighting boys.

The Motion Picture Industry, being conscious of its responsibility to the public, realized in the pre-war days that television was another, and possibly companion, development for presenting visual and aural actions in theaters. Experimentation in the pre-war years with Theater Television had proved that it was feasible both in England and here in the United States of America. Large-screen Theater Television on 15 X 18-foot screens made its debut in London, England, in February of 1939, and by the end of 1939 five theaters were equipped. Large-screen Theater Television made its debut in New York City during 1940 and was demonstrated experimentally on 15 X 20-foot screens in two New York theaters in 1941. Plans to

offer Theater Television on a commercial basis were interrupted by our entry into the war.

The Motion Picture Industry has a definite and legitimate interest and stake in television since this industry is in the business of producing popular entertainment and presenting news through visual and aural means. Obviously, television can bring that form of entertainment and news into the theater. Numerous reasons exist why the Motion Picture Industry must maintain a position in television. Some of these are:

(1) *Leadership*: The American Motion Picture Industry has, during the past fifty years, been the leader of the world in that industry. The industry has built a great record of accomplishments, and through its devoted and successful effort entertains over a hundred million persons weekly, including our armed forces.

(2) *Competition*: Television is another means to bring the visual and aural presentations into the theater. If Television Broadcasting comes into the home, the industry, through the theater, must be prepared to present some material related to that given in the home, and certain additional material, both on a larger scale. It must do a better job by adapting the medium to the theater. The producing branch or the showmen of the industry can be trusted to improve the medium as energetically and with as attractive inspiration as in the past. By such competition all phases of the television art, both in theaters and in the home, will benefit, as the industry will undoubtedly make important engineering contributions, and its exploitations into the artistic and entertainment phase should be of benefit and stimulation to all.

(3) *News Service*: The industry's presentation of news to the public in the theaters is one of its great contributions. Very extensive organizations are established to gather and arrange such visual and aural news and to distribute by the most rapid means of transportation, such news to the theaters promptly for visual and aural presentation. Television being able to record news events only as they occur (unless they are first recorded on film) is therefore an essential theatrical news presentation. Because of the fact that television does record the visual and aural news as they occur, the theater cannot afford to ignore it and has every reason to utilize it.

(4) *Insurance*: Acceptance of Theater Television by the public of such initial events as news, operas, or other events as they occur, and the obvious technical improvements in quality, brightness, contrast, detail, and possibly addition of color by the industry during the experimental and early commercial periods may be of such character that television as a medium may accompany or supplement film as a medium for presentation of visual and aural entertainment and news in the theater, and perhaps even supersede film presentations in part. This may prove to be farfetched. Nevertheless, the Motion Picture Industry cannot afford to be totally unprepared for such a change to Theater Television in the event that in addition to the instantaneous factor, Theater Television in some remote future also gives improved quality over film and is economically sound.

(5) *Broadcasting:* The Television Broadcasting Industry has in the past relied upon the Motion Picture Industry to supply motion picture films as a medium for them to use for program material in public Television Broadcasts. This need by the television broadcasters obviously will continue, and certain companies in the Motion Picture Industry have prepared plans for producing and supplying the television broadcasters with such motion picture productions which meet the television broadcaster's requirements. The technique of constructing a program with all of its ramifications of script writing, direction, and artistry with its associated scenery and lighting techniques is not only the backbone but also an outstanding accomplishment of the Motion Picture Industry. The television broadcasters are therefore at present reliant upon the Motion Picture Industry to produce film programs of the greatest entertainment or educational value to the public. The Motion Picture Industry therefore has been, and is now, television-minded, and its activities in this new art of television will presumably expand to meet the needs of the television broadcasters and of their own, theatrical-television requirements for economical film programs of quality comparable to other media of entertainment.

(6) *Parity with Broadcasting:* Television Broadcasting and Theater Television, as industries, are closely linked. Both are methods of producing, distributing, and exhibiting pictures in motion with related sound. Both industries are public servants in the sense that both, through this new medium of television, transmit entertainment and information to the public for its amusement, education, and benefit. The Television Broadcasting Industry presents this entertainment to the home through commercial sponsorship of the program. The Theater Television Industry will present such entertainment to the public in theaters to which an admission is charged. This similarity in service to the public between these two industries is reasonable justification for requesting that allocation of frequencies in the radio spectrum used for transmission by these two industries be on a parity of opportunity basis to encourage development and expansion of both industries on a sound and healthy formula. Both industries have a public place in the television art and both industries should be alike encouraged to progress.

By a "parity basis" is not necessarily meant a mathematical equality in channel widths, number of channels, and places in the frequency spectrum between Theater Television and Television Broadcasting.

By a "parity basis" is rather meant an equality of opportunity to develop both arts, and an equality of conditions under which their commercialized services may be carried on. All circumstances of allocation and system standards of the two arts should be carefully selected and given governmental sanction in such fashion that each art, within its domain, shall have equal opportunity to experiment, to commercialize, to improve, and to expand to its proper and demonstrable limits.

This may lead to one or the other art receiving wider channels or more channels, or channels in a different frequency range from the other art. No inequity would thus result. For instance, Theater Television may require wider channels for its wide-screen color-television pictures, may require more such channels for operating and intra-industry competitive reasons, and may desire such channels on higher frequencies than those for Television Broadcasting in order fully to

utilize certain directional possibilities. It is not meant to assert that Theater Television *will* need such facilities, but it is meant that a parity of opportunity between Theater Television and Television Broadcasting might conceivably lead to such requirements.

The Society of Motion Picture Engineers has for the past six years been actively engaged in engineering study of the requirements for Theater Television and has participated vigorously in the engineering considerations of the National Television Systems Committee and the Radio Technical Planning Board. After extended considerations, the Society of Motion Picture Engineers submitted resolution dated September 18, 1944 (P6-571-A) and resolution dated September 27, 1944 (SMPE-595-A) (attached hereto as Exhibits 1 and 2, respectively), to the Federal Communications Commission, requesting specific frequency allocations for immediate post-war Theater Television and additional frequency allocations for the anticipated ultimate growth of this new Theater Television Industry.

Major companies in the Motion Picture Industry have indicated that at the end of the war, or as soon as wartime requirements permit, they will enter into experimentation with the production and exhibition of Theater Television programs in specific local theaters with transmission of such programs to other specific theaters located in distant cities. The Society of Motion Picture Engineers has studied from an engineering aspect the technical requirements for such an initial Theater Television Industry and the ultimately expanded requirements of this new industry to place it on as complete and competitive a basis as is the present Motion Picture Industry.

Theater Television, in the immediate post-war period, will undoubtedly be experimentally presented to the theatrical public in monochrome, possibly using present standard of 525-line definition. Improved picture quality in monochrome comparable to 35-mm motion picture film, and later addition of color, will undoubtedly be required eventually if Theatrical Television presentations are to meet the public needs on a comparable basis with motion picture film presentations. The Motion Picture Industry, therefore, to present Theater Television to the public with somewhat the same picture quality as present film presentations, is required to contribute technically to the perfection of television in general and may be expected to do so. The frequency channel widths required for the transmission or relaying of such programs are as follows:

(1) *Monochrome Transmission:* 20-mc channel widths suitable for 525- to 800-line definition.

(2) *Monochrome Higher Definition and Color Transmission:* 40-mc channel widths suitable for higher definition monochrome comparable to present 35-mm film definition and for 3-color transmission of approximately 750-line definition.

The channel widths recommended are based upon having adequate channel widths for initial post-war experimentation and may later be decreased or increased in width dependent upon results of field tests.

Theater Television, as an industry, is expected to grow rapidly in years to come and it is believed that eventually 25 independent producing and exhibiting agencies may compete in an area such as New York City. For the initial post-war period experimentation of Theater Television it is recommended that frequency allocation requirements be provided for 15 producing or exhibiting agencies in an area such as New York City. Each agency, to produce and distribute one Theater Television program to specific local theaters and to relay this program to specific distant theaters, as diagrammatically shown on Plan Layout (Fig. 1, attached hereto), will require frequency allocations for the following stations or services:

(1) *Intra-City Studio Transmitter Station:*

- (a) 1 fixed studio to transmitter channel (point-to-point).
- (b) 1 cleared mobile transmitter channel (remote pickup).

(2) *Intra-City Multiple Addressee Station:*

- (a) 1 cleared transmitter channel for private multiple-directive transmission from single transmitter to a group of specific addressee theaters within the service area of the transmitter.

(3) *Inter-City Relay:*

- (a) 1 channel for interconnecting cities, for transmission of Theater Television programs simultaneously from a number of specific multiple addressee stations and/or directly to a specific theater or theaters in interconnecting cities.

This immediately necessary post-war Theater Television service, as distinguished from the ultimate service, will require a frequency band allocation of 1500 megacycles in channels of 20 megacycle widths preferably wholly contiguous or contiguous in substantial groups, in the radio spectrum between 300 and 6300 megacycles.

Additional requirements for the ultimate fully expanded industry on a large national competitive scale are as follows:

- (1) Improved definition or addition of color, both requiring wider channels.
- (2) Additional station requirements per agency for multiple and diversified

programming of Theater Television, respectively, to large central theaters and to neighborhood theaters.

(3) Extra mobile transmitter channel per agency, thus increasing flexibility of programming.

(4) Extra relay channel per agency for dual-program or two-way relaying.

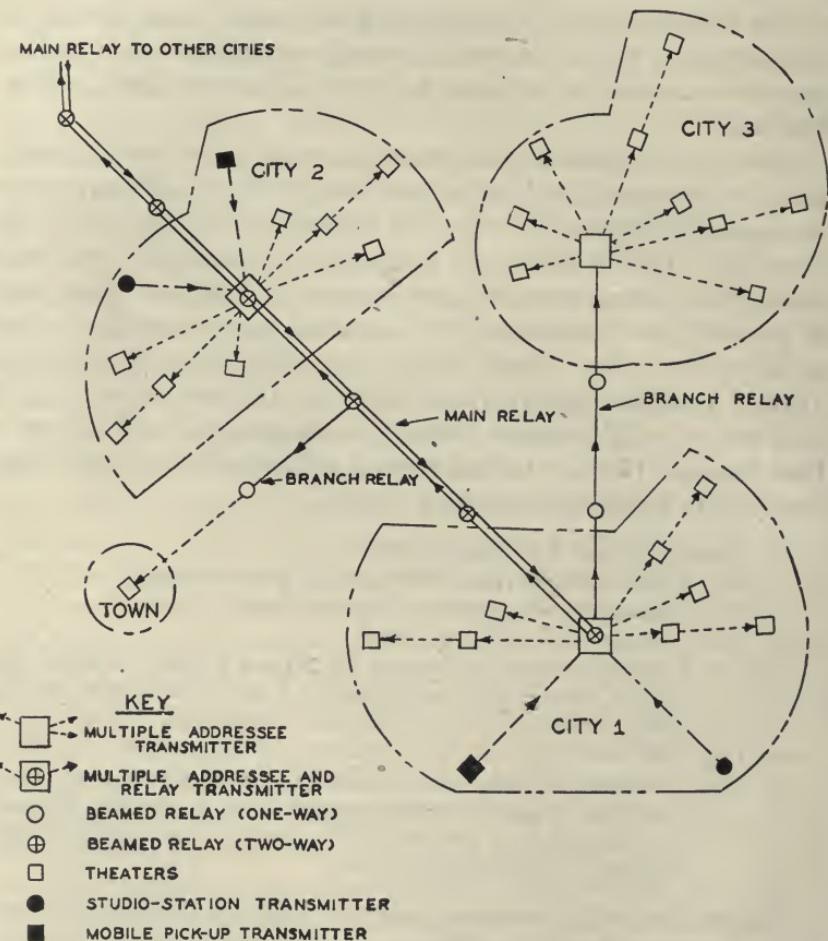


FIG. 1. Plan layout of proposed theater television distribution per agency. (Appendix 1, Society of Motion Picture Engineers.)

This additional expanded service will undoubtedly require additional frequency band allocations in the radio spectrum above 6300 megacycles and up into the tens of thousands of megacycles.

The complete picture for this ultimate fully expanded industry is naturally remote at this time and it is subject to revision in kind and

extent, based upon field tests, the results of the immediate post-war experimentation in Theater, Television transmission and, last but not least, upon public acceptance. However, the belief that additional requirements will be needed is presented at this time so that the Federal Communications Commission may be cognizant of the fact that additional frequency allocation requirements will be needed for a fully expanded Theater Television Industry.

The Society of Motion Picture Engineers submits the following information in respect to the evaluation of the service from the standpoint of public need and benefit as requested by the Federal Communications Commission in Public Notice No. 77289:

(1) *Radio Versus Wire Lines:* Theater Television involves the transmission of visual and aural actions from a suitable central transmitting station in a given urban area and sending therefrom highly directional beams of radiation to directional antennas and associated receivers located at the theaters. Such transmission could be classified as a multiple-addressee point-to-point communication system of private nature. The transmission would be high-fidelity television, perhaps using channels between 20 and 60 megacycles wide. Radio communication is preferred in practice whenever a number of points must be simultaneously reached from a single transmitting station and also when the type of communication uses such wide frequency bands as television. Present wire line facilities, including coaxial transmission lines, are not suitable, according to the best information available, for transmission of channel widths greater than 4 megacycles. Wire methods remain to be proved economically as to their feasibility and from an operating standpoint, including the factors of flexibility and convenience.

Mobile pick-up necessary for the transmission of news events to the central transmitter of necessity requires radio transmission. It is obvious that as a general rule, wire facilities would not be available nor, in some instances even possible (pick-up from moving vehicles). The relaying of Theater Television programs from the central station to remote cities seems at present to be feasible only by use of radio linkage systems.

The Society of Motion Picture Engineers feels that it is justified in urging that facilities be provided to determine the degree of utility of radio transmission for Theater Television, both on its own merits and in performance and economic comparison with alternative wire methods. To insure early post-war initiation of Theater Television, frequency allocations in the radio spectrum for this service are essential. Theater Television should not be handicapped in its initial experimental operations by being limited to a specific method of transmission. The Motion Picture Industry will obviously, when suitable wire line facilities are available, consider employing this method of transmission for Theater Television whenever such facilities are technically and economically practical.

(2) *Public Benefit:* On the assumption that 50 theaters are served from a single multiple-addressee transmitting station, and if the average seating capacity per theater is 1200 or a total seating capacity of 60,000, it can be assumed that

between one-quarter and one-half million persons will be served weekly by such a group of theaters. The Motion Picture Industry has over 85,000,000 attendance per week according to the best available figures, or approximately four and a half billion individual presentations or attendances per year. Ultimately a substantial fraction of this number may receive the benefits of Theater Television.

(3) *Public Support:* The support which Theater Television is likely to receive will of course depend upon its feasible quality and the audience response to it. It is believed, however, that the leaders in the Motion Picture Industry, being excellent showmen, will not fail to develop methods for utilizing the entertainment and educational values inherent in Theater Television.

Motion pictures are well known as a major means of entertainment and instruction. They have brought interest into urban and rural life on a large scale. They have relieved the tension of many people and have been a marked stimulant to personal and national morale. It is believed that Theater Television will in time be a great factor in the advancement of understanding, education, and entertainment.

(4) *United States Leadership:* The United States is the world leader in the field of motion pictures. With the advent of Theater Television, the United States should maintain that leadership in this new field as well. Theater Television is commercially contemplated in other countries in the post-war period. The Motion Picture Industry, proud of its world leadership in the art of visual and aural presentations to the theatrical public, intends to maintain that world leadership, and therefore its engineers propose that frequency allocations be made available to initiate this new industry as soon as manpower and facilities are available. The initiation and expansion of this new Theater Television Industry, as visioned, will also add substantially to employment possibilities, a very desirable post-war measure. The necessary capital and enterprise both exist in the Motion Picture Industry.

(5) *Establishment of Service:* The frequency allocation requirements of 1500 megacycles recommended for the immediate initial post-war period should be made available on an experimental basis to agencies in a group of cities at the earliest date to permit experimental field tests to be carried out. The frequency allocations should be adequate to permit the establishment of mobile pick-up, studio to transmitter, central multiple-addressee transmitter and relay facilities, so that methods and scope of Theater Television can be carried forward expeditiously. After this experimental development of the field, Theater Television should be commercialized along the methods found most practical and economical.

SUMMATION

The Society of Motion Picture Engineers, in behalf of the engineers of the Motion Picture Industry, recommends that the Federal Communications Commission consider the need for providing adequate frequency band allocations for a national Theater Television Service, such frequency band allocations to be on a parity of opportunity with the frequency band allocations allotted to Television Broadcasting, above 300 megacycles.

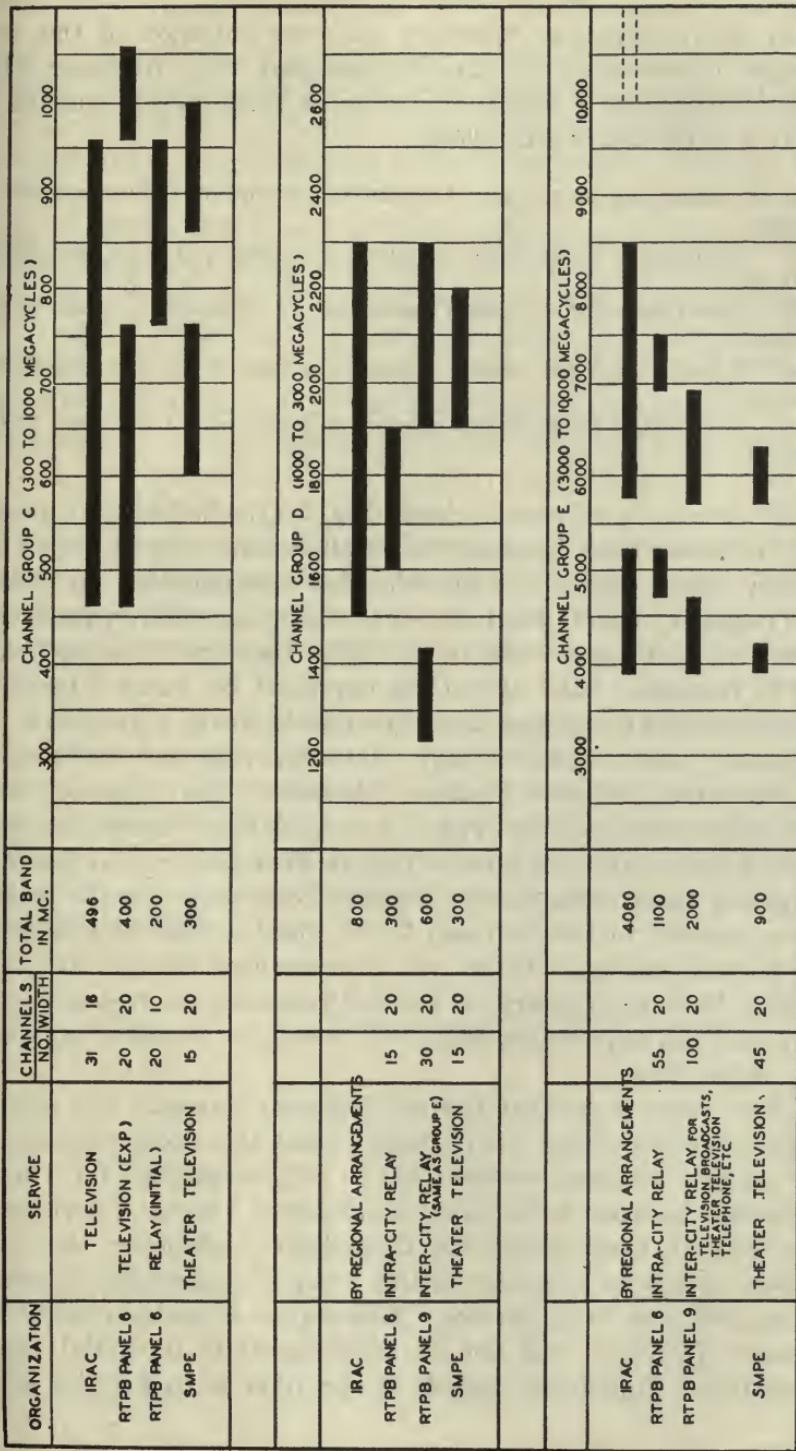


Fig. 2. Television frequency allocation requests. (FCC Docket No. 6651, Society of Motion Picture Engineers.)

For the immediately necessary post-war initiation of this new Theater Television Service it is recommended that a frequency band of 1500 megacycles in groups of contiguous 20-megacycle channels be allotted to this Service as follows:

- (1) 8 contiguous 20 mc cleared channels or a band of 160 mc from 600 to 760 mc.
- (2) 7 contiguous 20 mc cleared channels or a band of 140 mc from 860 to 1000 mc.
- (3) 15 contiguous 20 mc cleared channels or a band of 300 mc from 1900 to 2200 mc.
- (4) 15 contiguous 20 mc cleared channels or a band of 300 mc from 3900 to 4200 mc.
- (5) 30 contiguous 20 mc cleared channels or a band of 600 mc from 5700 to 6300 mc.

The frequency allocation chart (Fig. 2, attached hereto) graphically indicates these frequency band allocations compared with frequency band allocations for television recommended by IRAC, and frequency band allocations for television and relay, requested by Panels 6 and 9, respectively, of the Radio Technical Planning Board.

The frequency band allocations requested by Panel 6 for Television included the request that experimentation be permitted in the frequency bands requested above 300 megacycles and that such experimentation included Theater Television. The frequency band allocations requested by Panel 9 for relaying includes requests made by the Society of Motion Picture Engineers to that Panel for frequency band allocations for Theater Television. On the basis of these requests to Panels 6 and 9, for Theater Television Services, the specific frequency bands now recommended by the Society of Motion Picture Engineers for Theater Television are reasonable and on a parity of opportunity basis with Television Broadcasting above 300 megacycles.

The Society of Motion Picture Engineers earnestly and respectfully recommends that the frequency band allocations requested in the group C channels between 300 to 1000 megacycles for Theater Television be made immediately available to Theater Television by the Federal Communications Commission, whenever the Commission grants an allocation in this group C channel for Television Broadcasting or Relay Service. This request is made to insure that Theater Television will not be handicapped in its initial experimentation. Equipment capable of operation at frequencies within

group C channels has been developed and undoubtedly will be commercially available immediately upon release of the present wartime governmental regulations. Equipment for operation on frequencies above 1000 megacycles is not commercially developed and therefore will not be available upon such release. The Motion Picture Industry should not be handicapped in its desire to initiate this new industry promptly after release of wartime regulations.

The Society of Motion Picture Engineers also wishes to direct the attention of the Federal Communications Commission to additional frequency band allocations which may eventually be required for the ultimate fully expanded Theater Television Service. The extent of such additional frequency band allocation requirements to be determined after the initial experimental field tests of Theater Television.

The Society of Motion Picture Engineers also directs the attention of the Federal Communications Commission to the fact that Theater Television involves communications of a private nature and therefore should be accordingly classified to differentiate it from Television Broadcasting.

The Society of Motion Picture Engineers, in behalf of the engineers of the Motion Picture Industry, respectfully requests the Federal Communications Commission to grant the frequency band allocations recommended for initiating this immediate post-war industry of Theater Television so as to permit the American Motion Picture Industry to maintain its world leadership in the visual and aural entertainment field.

EXHIBIT 1*

**RESOLUTION UNANIMOUSLY PASSED BY THE
TELEVISION COMMITTEE OF THE
SOCIETY OF MOTION PICTURE ENGINEERS
MONDAY, SEPTEMBER 18, 1944**

Whereas, The Society of Motion Picture Engineers has been apprised of the hearing on frequency allocation for non-governmental services in the range of 10 kilocycles to 30,000,000 kilocycles, on September 28, 1944, before the Federal Communications Commission; and

Whereas, There is evidence that the motion picture industry will at the end of the war or as soon as wartime requirements permit, enter into presentation of Theatrical Television performances on a local and national scale; and

Whereas, The Society of Motion Picture Engineers views this evidence of such nature that specific recommendations for frequency allocations for immediate post-war activities and anticipated growth of this new industry of Theater Television seems proper at this time, to insure that this new industry will be on a parity with other visual services such as Television Broadcasting in respect to frequency band allocations for the services required; and

Whereas, This new industry of Theater Television desires to present to the Theatrical public locally and nationally Television of high definition in monochrome and in color when such color presentations are commercially feasible; the degree of definition being greater than that now contemplated for Television Broadcasting; and

Whereas, To insure the development of Theater Television on a national scale adequate provisions for frequency spectrum allocations should be provided for a probable twenty-five producing or exhibiting agencies in an area such as New York City, each such producing or exhibiting agency requiring the following stations or services in an area, per single program, for originating program, and for transmission of the program to local theaters and relaying to distant theaters:

- (1) *Intra-City Studio Transmitter Station*
 - (a) 1 Fixed Studio to Transmitter Channel (Point to Point)
 - (b) 2 Cleared Mobile Transmitter Channels (Remote Pick-up)
- (2) *Intra-City Multiple Addressee Station*
 - (a) 1 Cleared Transmitter Channel for multiple directive transmission from single transmitter to group of specific theaters within service area of transmitter.
- (3) *Inter-City Relay*
 - (a) 2 Channels for interconnecting cities for transmission of Theater Television programs, simultaneously from a number of specific multiple addressee stations and/or direct to specific theater or theaters in interconnecting cities; and

Whereas, The extension of Theater Television as a national service will expedite and expand technical developments to provide a higher degree of definition than now required for Television Broadcasting owing to visual comparison of Theater Television presentations with 35-mm Film presentations. This visual comparison will demand a higher definition picture and on the basis of present 35-mm Film presentations being of the order of 1200 lines the following channel widths for specific presentations are recommended:

- (1) *Monochrome Transmission*
20 mc Channel width suitable for approximately 800 line definition,
- (2) *Monochrome Transmission*
40 mc Channel width suitable for approximately 1200 line definition,
- (3) *Color Transmission*
60 mc Channel width suitable for 3 color system of approximately 750 line definition; and

Whereas, On the basis of the establishment of this new Art of Theater Television, on the basis outlined above, a total frequency band width of 18,000 mc will be needed; and

Whereas, The Society of Motion Picture Engineers realized that the motion picture industry could not establish such a complete Theater Television Service immediately, they wish however to present the above frequency allocation requirements for this service. However, for initiating the development of Theater Television as a new industry as soon as manpower and equipment are available it is recommended that the initial post-war frequency allocation requirements be based upon providing for 15 producing or exhibiting agencies in an area each capable of producing, transmitting, and exhibiting one program being a monochrome picture of 525 to 800 lines requiring a 20 mc channel width. For this initial programming the following stations or services are at least essential for each agency in an area:

- (1) *Intra-City Studio Transmitter Station*
 - (a) 1 Fixed Studio to Transmitter Channel
(Point to Point)
 - (b) 1 Cleared Mobile Transmitter Channel
(Remote Pick-up)
- (2) *Intra-City Multiple Addressee Station*
 - (a) 1 Cleared Transmitter Channel for multiple directive transmission from single transmitter to group of specific theaters within service area of transmitter.
- (3) *Inter-City Relay*
 - (a) 1 Channel for interconnecting cities for transmission of Theater Television programs, simultaneously from a number of specific Multiple Addressee Stations and/or direct to specific theater or theaters in interconnecting cities.

This immediately necessary post-war Theater Television Service (as distinguished from the foreseen later requirements) therefore require a frequency band alloca-

tion of 1200 mc in channels of 20 mc width preferably wholly contiguous; or contiguous in substantial groups; now therefore, be it

Resolved, That the Society of Motion Picture Engineers directs the attention to the Federal Communications Commission and industry representatives (RTPB) to the need for providing adequate frequency band allocations for a national Theater Television Service on a parity with the frequency band allocations allotted to Television Broadcasting; and

Be it Further Resolved, That for immediate post-war initiation of this new Theater Television Service a frequency band of 1200 mc be made available in contiguous channels of 20 mc width as follows:

- (1) 30 contiguous channels 20 mc wide or a band of 600 mc in the radio spectrum between 1000 and 3000 mc.
- (2) 30 contiguous channels 20 mc wide or a band of 600 mc in the radio spectrum between 3000 and 6000 mc; and

Be it Further Resolved, That for future expansion of this Theater Television Service another frequency band of 10,000 to 20,000 mc in groups of contiguous 20 mc channels (obviously in the radio spectrum above 6000 mc and up in the tens of thousands of mc) be set aside for expanded and improved services such as more agency transmitters, multiple programming of Theater Television to large and neighborhood theaters, extra channel per agency for mobile Pick-up, extra channel per agency for relay and expanded band width required for higher definition monochrome picture or color picture; this additional frequency band or fractions thereof to be preferably set aside on a parity basis with Broadcast Television frequency allocations in the radio spectrum above 6000 mc whenever this frequency range is allocated for experimentation or commercial comparable services; and

Be it Further Resolved, That the Society of Motion Picture Engineers assure the Federal Communications Commission of its desire to co-operate with it in behalf of the Motion Picture Industry and itself to the end that a fair and equitable allocation of frequencies be provided for all services using the radio spectrum.

EXHIBIT 2*

**RESOLUTION PASSED UNANIMOUSLY BY THE
TELEVISION COMMITTEE OF THE
SOCIETY OF MOTION PICTURE ENGINEERS
SEPTEMBER 27, 1944**

Whereas, The Society of Motion Picture Engineers has been apprised of the hearing on frequency allocation for nongovernmental services in the range of 10 kilocycles to 30,000,000 kilocycles, on September 28, 1944, before the Federal Communications Commission; and

Whereas, On September 18, 1944, the Television Committee of the Society of Motion Picture Engineers passed unanimously a Resolution of same date outlining specific frequency allocations for Theatrical Television, which Resolution has been directed to the attention of the Federal Communications Commission and industry representatives (Panels 1, 2, 6, 8, and 9 of the Radio Technical Planning Board); and

Whereas, Since submitting the aforesaid Resolution, the Society of Motion Picture Engineers has been apprised of the availability of frequency allocations in the frequency spectrum in Channel Group C (300 to 1000 mc) for Television Services, and in view thereof, by this Resolution, desires to modify its original frequency allocations outlined in the aforesaid Resolution as in the opinion of the Society of Motion Picture Engineers, allocation of frequencies within this Channel Group C for Television Services should be allocated on a parity basis between the different types of Television Services, namely, Television Broadcasting and Theater Television; and

Whereas, For an immediately necessary post-war Theater Television Service, Equipment will be more readily obtainable and adaptable for transmission and reception in this lower frequency Channel C than for the higher frequency Channel D and it is the desire of the Motion Picture Industry to initiate this new Theater Television Industry at the earliest possible post-war date and therefore does not wish to be handicapped in this endeavor or to be penalized more than other Television Services; and

Whereas, On the basis of this availability of frequency allocations in Channel Group C (300 to 1000 mc) the Society of Motion Picture Engineers desires to modify the frequency band allocations requested in Resolution dated September 18, 1944, to the following specific frequency band allocations, totaling 1500 mc, for immediately necessary post-war Theater Television (as distinguished from the foreseen later requirements outlined in aforesaid Resolution):

- (1) 8 contiguous 20 mc cleared channels or a band of 160 mc from 600 to 760 mc,
- (2) 7 contiguous 20 mc cleared channels or a band of 140 mc from 860 to 1000 mc,

- (3) 15 contiguous 20 mc cleared channels or a band of 300 mc from 1900 to 2200 mc,
- (4) 15 contiguous 20 mc cleared channels or a band of 300 mc from 3900 to 4200 mc,
- (5) 30 contiguous 20 mc cleared channels or a band of 600 mc from 5700 to 6300 mc; and

Whereas, The Society of Motion Picture Engineers wishes to clarify that the transmission of Theater Television is a private point-to-point service and therefore may be classified as a communication point-to-point service as differentiated from Television Broadcasting, the Multiple Addressee Stations referred to in the aforesaid Resolution is a transmitter having multiple beamed antenna array for beaming to specific theaters or points within the service area of the transmitter for private pick-up of transmission; now therefore, be it

Resolved, That the Society of Motion Picture Engineers directs the attention to the Federal Communications Commission and industry representatives (RTPB) to the need for providing adequate frequency band allocations for a national Theater Television Service on a parity with the frequency band allocations allotted to Television Broadcasting; and

Be it Further Resolved, That for immediate post-war initiation of Theater Television, the frequency band allocations requested in Resolution dated September 18, 1944, be modified to a total frequency band of 1500 mc in groups of contiguous 20 mc channels as follows:

- (1) 8 contiguous 20 mc cleared channels or a band of 160 mc from 600 to 760 mc,
- (2) 7 contiguous 20 mc cleared channels or a band of 140 mc from 860 to 1000 mc,
- (3) 15 contiguous 20 mc cleared channels or a band of 300 mc from 1900 to 2200 mc,
- (4) 15 contiguous 20 mc cleared channels or a band of 300 mc from 3900 to 4200 mc,
- (5) 30 contiguous 20 mc cleared channels or a band of 600 mc from 5700 to 6300 mc; and

Be it Further Resolved, That in view of the essentially private nature of such Theater Television Service, namely, communication of multiple messages under private auspices for ultimate viewing by the public in specific theaters, the Society of Motion Picture Engineers respectfully requests the desirability that these communications be correspondingly classified.

STATEMENT PRESENTED BEFORE FEDERAL COMMUNICATIONS COMMISSION RELATING TO TELEVISION BROADCASTING *

PAUL J. LARSEN**

Ed. Note.—In addition to the statement on allocation of frequencies in the radio spectrum for theater television service, presented before the FCC by Paul J. Larsen as Representative of the SMPE, Mr. Larsen also submitted a personal statement relating to recommendations made by various interests for commercial television broadcasting. This statement, accepted by the FCC as Exhibit No. 432, presents historic facts of the motion picture industry for the benefit of the FCC in arriving at a conclusion on the frequency band allocations required for a commercial television broadcast service, and is reprinted here.

Mr. Chairman and Members of the Commission:

During this hearing on Television Broadcasting various recommendations for immediate post-war frequency band allocations have been submitted by different interests. The Commission is confronted with determining the frequency band allocations to be granted for immediate post-war initiation of Commercial Television Broadcasting, based upon the following recommendations:

(1) *By the Radio Technical Planning Board:* Frequency band allocations between 60 and 260 megacycles, using the standards recommended by them for 525-line monochrome transmission.

(2) *By Other Interests:* An indefinite experimental period for the purpose of developing and field testing higher definite monochrome and color television, both requiring wider frequency band widths, necessitating allocations in the radio spectrum around and above 450 megacycles.

To assist the Commission in their determinations, I submit for their consideration certain historic and economic facts of the Motion Picture Industry. These facts should be of assistance in ascertaining whether or not color is essential and economically sound for immediate post-war Television Broadcasting.

The following tabulation presents chronologically the dates on

* Presented before the Federal Communications Commission (Docket No. 6651) on Oct. 27, 1944; FCC Exhibit No. 432.

** Washington, D. C.

which improvements in the art of motion pictures were demonstrated and commercialized. It is of interest to compare the date of the demonstration with the actual acceptance of the improvement by the Industry, as represented by the first public commercial performance.

MONOCHROME PICTURES

April 14, 1894: First public performance, monochrome, 16 frames, 60 feet per minute.

February, 1926: First public performance, monochrome, 24 frames per second, 90 feet per minute.

SOUND-ON-FILM

1921: First demonstration of sound-on-film on monochrome film.

April 15, 1923: First public theater performance in New York City of sound-on-film on monochrome film.

May 29, 1927: First commercial sound-on-film theater performance on monochrome film.

COLOR

March, 1909: First demonstration of 2 color (rotary filter disk separate films). Process known as "Kinemacolor."

Sept. 12, 1918: First public theater performance of 2-color subtractive process known as "Kestacolor." Presentation of "The American Flag."

1923: First demonstration in Paris of 3-color additive process known as "Keller-Dorian." Later known as "Kodacolor."

1926: First public theater performance in U.S.A. of 2-color subtractive process known as "Technicolor."

1933: First commercial theater performance in New York City of 3-color subtractive process known as "Technicolor" with sound-on-film.

During 1943, the following feature, short, and newsreel motion pictures were produced for theater consumption by the Motion Picture Industry. It is of interest to note that of the total features produced only 13 per cent were in color, and of the shorts produced only 37 per cent were in color.

	In Monochrome	In Color	Total
Feature Pictures	368	50	418
Shorts	329	120	449
Newsreels	502	0	502

The following approximate quantity of positive film stock was used for the print release to the theaters for the above motion pictures:

Positive Stock Monochrome.....	1,660,000,000 feet
Positive Stock Color.....	140,000,000 feet

The studio production costs for color features are approximately 20 to 35 per cent higher than comparable productions in monochrome,

based upon the best available information. The average cost of a grade *A* feature production in monochrome is in the neighborhood of \$700,000, varying between \$400,000 and \$2,000,000. The average cost of single-reel shorts or a grade *B* or *C* feature, per reel in monochrome, is approximately \$30,000, varying between \$10,000 and \$80,000. This 20 to 35 per cent higher cost for color is therefore a substantial increase in the cost of such productions.

In addition to the initial higher cost of production of color pictures, the cost of the release prints is also a major economic factor. The average cost per foot of a monochrome film is approximately $1\frac{1}{2}$ cents, whereas the cost per foot of a color film is approximately 6 cents. On the basis of an average of 250 positive prints per feature and short, and 725 prints per newsreel being required, this increased film cost is a major item.

The above facts and figures are submitted to assist the Commission in its determination of factors involved between monochrome and color Television Broadcasting. From the above it will be noted that the Motion Picture Industry was established and became a large industry even though up to and including the year 1932, all of its presentations were in monochrome. In 1932 their gross income amounted to \$1,100,000,000. Color was commercially accepted in 1933 and it is of interest to note that even as late as 1943, only 13 per cent of the total feature pictures produced were in color. Public acceptance of theatrical motion pictures prove, by the above facts, that it is not based upon whether such pictures are in monochrome or in color, but are based upon the entertainment value of the contents of the pictures. The majority of the features which have won acclaim by the public and received the Academy of Motion Picture Arts Award, have been in monochrome.

My personal opinion is that the Television Broadcasting Industry has more major problems to solve than whether their transmission should be in monochrome or in color. One of the first and most important problems confronting the Television Broadcasters is the economic factor, and the addition of color will only make this factor worse. The second most important is to develop the technique to produce, whether by live talent or by film subject, the proper type of program material which will meet public acceptance from an entertainment value and meet the advertisers' requirements, warranting them to sponsor the program.

The Television Industry, whether it is Television Broadcasting or

Theater Television, has also many technical problems to solve and improve before considering the addition of color. Major improvements are required to increase the contrast range of the over-all system. This factor of contrast range has a great bearing upon the definition attained. Motion picture productions have an average contrast range of 30 to 1, whereas the best contrast range attainable in present television is of the order of 15 to 1 on monitors employed at the transmitting station, and approximately 10 or 12 to 1 on a home receiver.

A second technical problem requiring improvement is the utilization of the ultimate line definition which can be obtained using the present standard of 525 lines. On a home television receiver it should be possible to obtain definition in the order of 480 lines, allowing for blanking. In the writer's opinion, the average definition now attainable on post-war home television receivers, modified and improved during the past few years, is about 260 lines. The above required improvements are not easy to accomplish and by themselves will undoubtedly require many years of continued development to attain the ultimate desired performance indicated. Their solution must be attained before color is even considered experimentally.

Commercialization of Television Broadcasting, by the allocation of the frequencies, and employing the standards recommended by the Radio Technical Planning Board when Governmental regulations permit such commercialization, will spur the Radio Industry into a frenzy of activity heretofore unseen. Many newcomers, both manufacturers and radio engineers, will appear in the Television Industry and their concerted industrious effort on a competitive basis will result in the ultimate performance characteristics of television capable under these standards being expeditiously attained.

I submit that the frequency band allocations and standards recommended for immediate post-war commercial Television Broadcasting by the Radio Technical Planning Board are commercially satisfactory for a Television Broadcasting Service and that the allocation of frequencies in the group C channels recommended for experimental television, by the Radio Technical Planning Board, of new high-definition and color television, is a reasonable and sound recommendation and I concur therewith. The frequency band allocations recommended in the group C channel are recommended so as to permit experimentation of improved methods and systems over a

sufficient period of time to ascertain whether such improved method or system is desirable and practical technically, economically, and commercially.

The experience of the Motion Picture Industry and the previous experience of the Television Industry proves that the adoption commercially of new methods, systems, and improvements such as, for example, the addition of sound and color by the Motion Picture Industry, and the standardization of synchronization, line frequency, and type of modulation by the Television Industry does not happen overnight. All such recommended or proposed methods, systems, or improvements require extensive study, extended laboratory developments, and extended field trials to ascertain whether such recommendation or proposal is practical, economical, and commercially sound. In the writer's opinion, the increase in definition or the addition of color to the present standardized and field tested Television Broadcasting system, will require many years of laboratory development, and, beyond that stage, additional years of field testing under all types of field conditions to insure that the improvements are technically, economically, and commercially practicable and not just laboratory dreams. The experimental channels recommended by the Radio Technical Planning Board insure proponents of new methods, systems, or improvements, that development and field testing of such proposals can be carried out orderly by the Industry, and the Television Industry will determine after adequate field tests whether or not the proposed method, system, or improvement is technically sound and commercially practical, and last but not least, that the service, the picture quality, and the entertainment value are enhanced to the public.

EXCERPTS FROM REPORT BY FEDERAL COMMUNICATIONS COMMISSION ON PROPOSED ALLOCATIONS FROM 25,000 KILOCYCLES TO 30,000,000 KILOCYCLES *
(DOCKET NO. 6651)

Ed. Note.—The SMPE applied to the Federal Communications Commission for specific frequency allocations for experimental television channels to make possible the direct pickup of programs from motion picture film studios and elsewhere for transmission to theaters within a given city or to relay programs to theaters in distant cities. (See pp. 105-122 of this issue.)

Excerpts taken from the report issued by the FCC on proposed allocations indicate that ample opportunity is provided for experimentation on pickup and intra- and inter-city television transmission. The motion picture industry therefore is now privileged to submit applications to the Commission for experimental authorization in the frequency bands specified for these purposes.

PART I

DESCRIPTION OF THE COMMISSION'S PROCEEDINGS AND STATEMENT OF ITS PROPOSED ALLOCATIONS

SECTION 4—GENERAL PRINCIPLES FOLLOWED BY COMMISSION IN MAKING PROPOSED ALLOCATIONS

"As appears from the preceding section, in most cases the request for frequencies by the various non-governmental radio services far exceeded the supply and in some of these cases the evidence showed little or no correlation between the number of channels requested and the number and locations of the units or stations proposed to be installed. Hence, the Commission could not in all cases propose an allocation based strictly upon the number of channels requested. Furthermore, the engineering standards or basis upon which channel widths were estimated appeared somewhat conflicting, thereby necessitating a detailed examination of all the engineering facts presented in order that a proper adjustment of these conflicts could be made. As has been pointed out, some of these requests were completely unsupported by adequate engineering studies or satisfactory technical data, and therefore had to be rigidly discounted. Even after this was done, the demand for frequencies still far exceeded the supply. This was true throughout the entire spectrum. It was therefore obvious that all of the requests based upon statements as to the number of channels required could not be met, and in most instances, the Commission has had to allocate fewer or narrower channels than were requested or assign the service to a different portion of the spectrum from that sought, or both.

"There were six general principles that guided the Commission in making this determination. In the first place, the Commission examined each request to determine whether the service in question really required the use of radio or

* No. 79776, dated Jan. 15, 1945.

whether wire lines were a practicable substitute. Obviously, with the severe shortage of frequencies, it would not be in the public interest to assign a portion of the spectrum to a service which could utilize wire lines instead. The Commission's determination was not limited to technical considerations but also took into account economic and social factors and considerations of national policy. For example, while fixed point-to-point service between countries could be carried on by cable as well as by radio, the great disparity in costs between the two types of service and considerations of national policy clearly required the assignment at least at this time of frequencies for such fixed point-to-point service.

"As a second principle, the Commission determined that not all radio services should be evaluated alike. Radio services which are necessary for safety of life and property obviously deserved more consideration than those services which are more in the nature of conveniences or luxuries.

"Thirdly, the Commission was concerned with the total number of people who would probably receive benefits from the particular service. Where other factors were equal, the Commission attempted to meet the requests of those services which proposed to render benefits to large groups of the population rather than of those services which aid relatively small groups.

"Fourth, and this applied particularly to proposed new services, the Commission undertook to determine whether such newer services met a substantial public need and what the likelihood was, if frequencies were granted, that the service could be established on a practical working basis. With the shortage of frequencies available, the Commission did not believe that it would be in the public interest to assign frequencies to a new service unless it could be shown that there would be public acceptability and use of the service.

"The fifth principle related principally to consideration of the proper place in the spectrum for the service in question. There was much evidence introduced in the record—some of it available for the first time—concerning the radio wave propagation characteristics of the various portions of the spectrum. This evidence showed that operation on frequencies within certain regions of the radio spectrum was more suitable for some types of services than others. Certain frequencies could be more effectively used by those services where long range communication was necessary. Other frequencies were better suited for short range communication. In the case of some frequencies, the principal source of interference to a station on these frequencies would be from stations located nearby, while in the case of other frequencies the principal source of interference would be caused by distant stations. All of these factors had to be evaluated so that the service could be assigned to that portion of the spectrum where it could render its best service.

"The sixth principle also pertained to assignment of each service to the proper place in the spectrum. In determining the competing requests of two or more services for the same portion of the spectrum, when one or more of the services was already operating in that portion of the spectrum, the Commission gave careful consideration to the number of transmitters and receivers already in use, the investment of the industry and the public in equipment, and the cost and feasibility of converting the equipment for operation on different frequencies, as well as to the time required for an orderly change to the new frequencies.

"The limited available spectrum space makes it mandatory that many services

prepare to employ much stricter engineering standards in future operations, such as improved frequency tolerances, reduced harmonic and other spurious emissions, better receiving equipment, etc. Most efficient use of the available spectrum space can only be realized by each station in all services employing the most improved techniques for the conservation of frequency space and by complete co-operation among the various services. Improvement in receiver performance is particularly important. For example, if the advantages of frequency modulation are to be obtained such as to warrant the required spectrum space, it is essential that well-designed frequency modulation receivers be provided. Such receivers must have proper selectivity, limiter and discriminator characteristics. Further, it is urged that no receivers for any service be manufactured which radiates an appreciable signal. A radiating receiver is in effect a low power transmitter often capable of causing serious interference to other receivers in the same or other services. The slight difference in cost between a well-designed receiver and one of poor design is more than offset by the gain to all services. It is expected that post-war receivers will be designed and manufactured so as to minimize the effects of image frequency response, radiation from beat frequency oscillators and other effects that may be directly attributed to equipments of inferior design and performance.

"The allocations which the Commission is proposing, and which are set out in section 5 of this Part for frequencies above 25,000 kilocycles, were arrived at by the application of the foregoing general principles."

PART II
DISCUSSION OF PROPOSED ALLOCATION BY SERVICES
SECTION 1—INTRODUCTORY

"The succeeding eighteen sections of this Part contain a discussion of the allocations which the Commission is proposing to make to the various non-governmental radio services from 25 megacycles to 30,000 megacycles. There is a separate section for each of the radio services or groups of related services which were made the matter of individual consideration at the hearing, and for convenience in referring to the transcript, each section bears the same number as does the appropriate volume or volumes of the transcript containing the testimony for the service in question.

"Each of the sections starts out with introductory material concerning the history and present status of the service in question. Then comes a table containing the names of the witnesses who testified concerning the particular service, the company or organization they represented, and the transcript pages where their testimony may be found. This is followed by a discussion of the various proposals which were made at the hearing and the allocation which the Commission proposes to make and the reasons therefor. In each case there is a full discussion of every proposal that was made at the hearing concerning the appropriate place in the spectrum, width of channel, and total number of channels. The sections indicate whether the requests were granted or denied and if denied the reasons for the denial are given.

"A word of caution should be added. Most, if not all, of the allocations which we propose at this time cannot be placed into effect until after transmitter, receiver and other materials, facilities and manpower again become available for

civilian use. The recent trend of events indicates that it will be necessary for the Commission to continue indefinitely, and perhaps strengthen its present policies restricting the use of critical materials and manpower for civilian radio purposes. The Commission, however, does believe that it is in the public interest to announce its proposed allocations at this time so that broadcasters, manufacturers of radio equipment and persons desirous of entering the radio field may be in a position to make whatever advance planning is necessary as soon as possible and so that adequate preparation may be made for future international conferences. In the meantime, the full efforts of the radio industry and the Commission must continue to be devoted to the prosecution of the war."

SECTION 17—NEW RADIO SERVICES IV—THEATER TELEVISION

"The proposed use of radio for theater television is intended to provide facilities whereby news, sporting events, operas, and other events can be televised and shown to the general public on large-size screens such as are normally used in motion picture theaters. It was claimed at the hearing that the motion picture industry has a definite and legitimate interest in television, since the industry is in the business of producing popular entertainment and presenting news through visual and aural means. It was estimated that over 85 million persons attended motion picture theaters weekly, and that the industry has a gross annual income of approximately \$1,600,000,000 (Tr. 3713-3716).

"It was stated that the major companies in the motion picture industry have indicated that, at the end of the war, or as soon as wartime requirements permit, they will begin experimentation with the production and exhibition of theater television programs in specific local theaters, and with the transmission of such programs, to theaters in distant cities. Certain experiments were conducted prior to the war which indicated that theater television might be feasible. Large screen theater television on 15' × 18' screens were shown in London during the year 1939, and were subsequently demonstrated experimentally in two theaters in New York City in 1941 on screens 15' × 20'. Further experimentation with theater television was discontinued after the entry of the United States into the war (Tr. 3715).

"The witness for theater television was Mr. Paul J. Larsen (Tr. 3711-3755), who appeared on behalf of the Society of Motion Picture Engineers.

"The number of channels requested was predicated on the possible demand for service in New York City. It was claimed that there were 42 competitive theatrical agencies in operation; however, it was believed that because of economic factors, only 25 of the 42 agencies could afford to enter the theater television field. For the initial post-war period experiments in theater television, it was recommended that frequency allocation be made for 15 producing or exhibiting agencies in an area such as New York City, each agency to produce and distribute one theater television program to specific local theaters and to relay this program to specific distant theaters. This would require three classes of stations or services, as follows:

- (1) Intra City Studio Transmitter Station:
 - (a) 1 fixed studio to transmitter channel (point-to-point).
 - (b) 1 clear mobile channel (remote pickup).

- (2) Intra City Multiple Addressee Station:
1 clear channel for private multiple-directive transmission from a single transmitter to a group of specific addressees within the service area of the transmitter.
- (3) Inter City Relay:
1 channel to interconnect cities, for transmission of theater television programs simultaneously from a number of specific multiple address stations to a specific theater or theaters in different cities.

"The requests for frequencies for theater television service include a total of 1500 megacycles in 75 20 megacycle channels as follows:

- (1) 8 contiguous 20 mc. clear channels or a band of 160 mc. from 600 to 760 mc.
- (2) 7 contiguous 20 mc. clear channels or a band of 140 mc. from 860 to 1000 mc.
- (3) 15 contiguous 20 mc. clear channels or a band of 300 mc. from 1900 to 2200 mc.
- (4) 15 contiguous 20 mc. clear channels or a band of 300 mc. from 3900 to 4200 mc.
- (5) 30 contiguous 20 mc. clear channels or a band of 600 mc. from 5700 to 6300 mc.

"It was stated that theater television in the immediate post-war period would undoubtedly be presented to the public in monochrome, possibly using the present television standard of 525 line definition. It was also claimed that improved picture quality in monochrome comparable to 35-millimeter motion picture film, and also the addition of color will undoubtedly be required if theatrical television presentations are to meet with public acceptance on a basis comparable with present motion picture film presentations. It was claimed that for a transmission of monochrome television, a band width of 20 megacycles would be required which would be suitable for 525 to 800 line definition. For monochrome of higher definition and for color transmission, a channel width of 40 megacycles would be required. This would permit a definition in monochrome comparable to the present 35-millimeter film definition and for three-color transmission of approximately 750 line definition. It was stated that ultimately the theater television industry would employ highly directive antennas and then would not require any frequencies below 10,000 mc. except in very rare cases where the terrain, for instance, would make it impossible to use frequencies above 10,000 mc. However, since it was questionable whether such transmitting and receiving equipment would be available immediately in the post-war period, requests were made for frequencies below 10,000 mc. in order to permit immediate experimental operation of the proposed service (Tr. 3725-3732).

"Since theater television is still in the experimental stage of development, the Commission does not propose to allocate any specific frequencies at this time. However, the Commission will give consideration to applications for experimental authorization involving intracity transmissions, including studio to transmitter, remote pickup, and intracity multiple address stations, on the frequencies between 480 and 920 megacycles allocated to broadcasting on the basis that the use of these frequencies will be discontinued when needed for the broadcast service. In addition,

tion, experimentation with intra- and inter-city relay of theater television programs may be authorized in the following bands of frequencies, namely, 1900-2300, 3900-4550, 5750-7050, 10,500-13,000, 16,000-18,000, and 26,000-30,000 megacycles, as discussed in section 19 of this part."

SECTION 19—RELAY SYSTEMS

INTRODUCTORY

"The allocation of frequencies for use by relays presently operated as links in fixed public point-to-point services and in connection with such radio services as police, forestry, and the like have already been considered and dealt with under the respective services. The types of stations here considered in connection with the allocation of specific frequencies for relay operations are the following:

- (1) those which are designed to be operated as common carrier systems;
- (2) those which are used for relaying programs in connection with individual broadcast services and in connection with certain point-to-point radio services not open to public correspondence.

"The Commission has promulgated no specific rules and regulations governing the operation of relay systems such as those dealt with in this section and no frequencies are now specifically allocated for that purpose. Authorizations for the stations now operating as relay stations of the types here considered have been granted on an experimental basis only. Proposals made at the hearing involve setting aside substantial portions of the radio spectrum for the exclusive use of relay systems. They are discussed more fully below.

"All the relay stations now authorized, with the possible exception of a few common carrier radio links and radio control and keying circuits, are operating, or have been authorized to operate within the frequency bands which the Commission now proposes to allocate for such purposes. Due to the fact that much experimental and developmental work remains to be done, any conclusions at this time with respect to the most desirable position in the spectrum for relay operations would appear to be premature. It is for this reason that the Commission is of the opinion that it is essential that all radio relay operations be presently authorized on an experimental basis only.

WITNESSES

"The witnesses who testified in connection with the proposed allocation of frequencies for relay systems were as follows:

Name of Witness	Representing	Tr. Pages
GLEN E. NIELSEN	F.C.C.	4140A-4142
ELMER W. ENGSTROM	Chairman, Panel 9 RTPB, also associated with RCA Laboratories, Princeton, New Jersey	4142-4158
WALTER S. LEMMON	Executive, International Business Machines Corporation, New York, N. Y.	4158-4163
H. B. FANCHER	Engineer, General Electric Company, Schenectady, N. Y.	4163-4168

RALPH BOWN	Director of Radio and Television Research, Bell Telephone Laboratories, New York, N. Y.	4168-4179
F. M. BRAMHALL	Transmission Research Engineer, the Western Union Telegraph Company, New York, N. Y.	4179-4185
JOSEPH PIERSON	Manager, Communications Division, Ray- theon Manufacturing Company, Walth- am, Massachusetts	4186-4195
JOHN A. DOREMUS	Engineer, Communications Division, Ray- theon Manufacturing Company, Walth- am, Massachusetts	4196-4200

"Included in the membership of Panel 9 of RTPB were representatives of the following companies and organizations:

RCA Laboratories, Inc.
 Bell Telephone Laboratories, Inc.
 Philco Corporation
 Federal Telephone and Radio Laboratories
 Sperry Gyroscope Company, Inc.
 Westinghouse Electric and Manufacturing Company
 General Electric Company
 A. B. DuMont Company
 International Business Machines Corporation
 U. S. Independent Telephone Association
 The Western Union Telegraph Company
 Society of Motion Picture Engineers
 Radio Corporation of America
 National Association of Broadcasters
 Hughes Productions
 Blue Network Company, Inc.
 National Broadcasting Company, Inc.
 Columbia Broadcasting System, Inc.
 Mutual Broadcasting System, Inc.

POSITION IN THE SPECTRUM, CHANNEL WIDTH, AND NUMBER OF CHANNELS

"Television and FM broadcast interests, as well as the recognized common carriers and many of the larger corporations, have submitted plans for the establishment of extensive radio relay systems. These organizations visualize nationwide networks of radio relay systems for the distribution of television programs, FM broadcast programs, standard broadcast material, multiplex telephony, high-speed telegraphy, facsimile, radio photo, business machine data and many other forms of modern communications.

"The testimony concerning radio relay systems was of a very general and indefinite nature for two reasons: (1) because most of the information concerning research work, tubes, and operating experience in the ultra-high and super-high frequencies was of a classified nature, and (2) such information as was available was

purely the result of experimental work in laboratories, there being no substantial practical experience under actual operating conditions. All witnesses, however, were in agreement that radio relay systems are both possible and practicable, and that available information indicated that use of the higher frequencies (above 1000 mcs) is preferable from both the technical and economic points of view. All witnesses proposed the development of radio relay systems as common carrier systems to provide facilities for radio transmission of all types of communications traffic, *i. e.*, including program and public and private communications.

"The witnesses generally agreed that a channel width of approximately 20 mcs was desirable—that these should generally be allocated in large blocks of from 250 to 400 mcs in order to permit the most economical design of equipment, that these blocks should be located near 2000 mcs, 4000 mcs, and a larger block 1000 mcs wide at approximately 12,000 mcs, with about one-third of all frequencies above 13,000 mcs allocated for relay use as they become available.

"The testimony indicated generally that relay stations would be spaced at intervals ranging from 20 to 40 miles, that the use of highly directive and narrow beams would permit the use of the same channel at alternate relay points, thereby requiring no more than two or three channels for the establishment of a one-way relay circuit, with double the number of channels necessary for simultaneous two-way transmission.

"All witnesses concurred generally in the recommendations of RTPB Panels 2 and 9.

"The proposals of the various witnesses are listed below:

"A—TELEVISION AND OTHER RELAY SYSTEMS:

(1) RTPB Recommendations as Revised November 1, 1944:

While RTPB Panels 2, 4, 5, 6, and 9 proposed several different groups of frequencies for the various relay services, representatives from these panels met November 1, 1944, and agreed upon the following bands as being satisfactory:

700-	900 mcs.	Temporary television relay
1225-	1325 mcs.	Portable and mobile relay
1900-	2300 mcs.	Relay
3900-	4450 mcs.	Relay
4450-	4550 mcs.	Intra-city relay (television)
5750-	6800 mcs.	Experimental relay—non-exclusive
6800-	7200 mcs.	Experimental intra-city relay (television)
10500-	13000 mcs.	Experimental relay—non-exclusive
16000-	18000 mcs.	Experimental relay—non-exclusive
26000-	30000 mcs.	Experimental relay—non-exclusive

(2) Theater Television Relays; Recommendation of Society of Motion Picture Engineers:

600-	760 mcs.	75 channels, 20 mcs. wide
860-	1000 mcs.	
1900-	2200 mcs.	
3900-	4200 mcs.	
5700-	6300 mcs.	

"B—COMMON CARRIERS:

- (1) American Telephone and Telegraph Company:

The A. T. & T. Company has requested the following frequencies for wide-band transmission of television, facsimile, sound programs, and multiplex telephony, using unattended repeater stations with highly directional antennas:

1900– 2300 mcs.	20 channels	20 mcs. wide
4000– 4400 mcs.	20 channels	20 mcs. wide
11500–12500 mcs.	? channels	? mcs. wide
Above 13000 mcs. 10 to 15 per cent of frequency space		

- (2) United States Independent Telephone Association:

This group requested the same frequency bands as those designated by the A. T & T. Company.

- (3) The Western Union Telegraph Company:

The Western Union Telegraph Company has requested the following frequencies for the purpose of relaying all forms of record communications on a common carrier basis, using unattended repeater stations with low power transmitters and directional antennas:

1900– 2300 mcs.	8 bands	25.3 mcs. wide
3900– 4550 mcs.	8 bands	26.4 mcs. wide
5700– 6900 mcs.	8 bands	27.6 mcs. wide
10500–13000 mcs.	8 bands	30.6 mcs. wide

- (4) Raytheon Manufacturing Company:

Raytheon proposes to construct and operate a transcontinental microwave relay communication system on a common carrier basis for a wide variety of services. The frequency bands requested are as follows:

1900–2000 mcs.
3900–4172 mcs.
5760–6022 mcs.

- (5) International Business Machines Corporation and General Electric Company:

The I.B.M. and G.E. companies have indicated that they wish to develop radio relay systems involving the commonly known types of emission and special emission for the transmission of modern business machine data. These companies are presently authorized to use six bands of frequencies 60 mcs. wide between 1900 and 2300 mcs. for the experimental operation of radio relay systems. It has been indicated that frequencies recommended for relay purposes by RTPB will be satisfactory to both I.B.M. and G.E.

THE COMMISSION'S PROPOSAL

"The Commission's proposed allocation of bands which will be available for assignment to fixed and mobile services, including radio relay systems, conforms almost exactly with the RTPB proposal:

1225-	1325 mcs.
1900-	2300 mcs.
3900-	4550 mcs.
5750-	7050 mcs.
10 500-	13 000 mcs.
16 000-	18 000 mcs.
26 000-	30 000 mcs.

The allocation is accompanied by the following note:

"Services will be established in these bands on an experimental basis pending adequate showing as to need and technical requirements."

"The 5750-7050 mcs. band represents an attempt to reconcile a conflict between the IRAC proposal embracing 5750-6900 mcs. and the final RTPB proposal of two bands, 5750-6800 and 6800-7200 mcs.

"It should be understood that no commitment is being made to the effect that these particular frequencies will be assigned for relay purposes on a permanent or commercial basis. The usefulness and adaptability of these frequencies for relay purposes can be proved only by experimentation under practical operating conditions.

"Until such time as the channels are required for television broadcast service, channels 9, 10, 11, and 12 (192 to 216 mcs) as well as channels in the band 480 to 920 mcs may be used for television relay."

SOME FACTORS IN DRIVE-IN THEATER DESIGN*

L. H. WALTERS**

Summary.—There appears to be every indication that in the immediate post-war years at least one drive-in theater will be constructed in every good-size town and city in the country. A brief discussion of the many factors which must be carefully considered by the builder of such a theater is given in the following paper.

The first drive-in theater of modern type was opened in 1933. In the 11 years which have elapsed since that time, activity and construction of drive-in theaters have gained considerable momentum. This type of theater—which yesterday was in the experimental stage and looked upon as something of a “freak”—is beginning to prove itself an important part of our industry.

The most recent issue of the *Film Daily Yearbook* indicates that in January 1943 there were 99 drive-in theaters in existence and a majority of them were located in Ohio, Texas, Massachusetts, Georgia, and Florida. The rest of them were spread out among a total of 29 other states.

It seems apparent that if it had not been for the restrictions to construction arising from the war effort, many more theaters would be in operation today. There is already considerable evidence of interest among a number of groups for building drive-in theaters after the war and in many localities sites have been selected and plans drawn.

In considering the design and construction of a drive-in theater, there are a number of problems which must be kept in mind. In this paper I will not attempt to cover the entire story but will merely mention some of the most outstanding factors in drive-in theater design which I have noted in my experience in this field.

Since the first theater was opened, a considerable amount of information and experience has been gathered which should, in the post-war period, result in much more effective and efficiently oper-

* Presented Apr. 17, 1944, at the Technical Conference in New York.

** National Theater Supply Company, Cleveland, Ohio.

ated theaters. It has been interesting to note that the original theory that there would be more "spooners" than anybody else at these theaters has not proved to be correct; the majority of patrons seem to be housewives who do not want to take the time to tidy and dress up after dinner, preferring to go directly from the kitchen to the theater via their auto. It has also been surprising to learn that outside noise distractions—such as street noises and automobiles on nearby highways—are not as much a factor as had been anticipated originally.

What factors should be considered in selecting the site?

In the design of a drive-in theater, the selection of the site is, of course, the first step and is of utmost importance as the success or failure of the project hinges upon the theater being properly located. Accessibility to highways must be placed at the head of the list for the same reason that an indoor theater should be located where the traffic is heaviest.

The ground selected for the site should be approximately the same level as the highway which it adjoins. If this is not true, the cost of properly grading the site would make the venture uneconomical. In any event, if the level is not satisfactory, there must be sufficient ground in the rear of the site to use as filling to assure perfect drainage.

If it is possible, it is very important that connecting water and sewage systems be located on the site. This reduces the initial investment for the theater. If they are not available, a well would have to be drilled to supply water and a cesspool would have to be constructed for sewage disposal.

The number of ramps for the drive-in theater is determined by the architect after the size of the site has been determined. The number of ramps will depend on the size of the site and the radius of the ramp. Obviously, the total capacity of automobiles which the theater will accommodate depends on the size and number of the ramps.

What factors govern the location and design of the screen tower?

Once the site of the drive-in theater has been selected, the location of the screen tower is important. The screen surface should not face the west because in certain localities the sun sets at such a late hour that it would necessarily affect the time at which the motion picture performance could commence and, of course, thereby affect the financial success of the venture.

The design of the screen tower is significant in that its height is determined by the size of the picture image, keeping in mind that good sight lines have to exist for each ramp and a fair margin of black must be allowed for masking the screen. Furthermore, the tower itself is subject to considerable wind pressure and weather conditions and the larger it is, the more important its construction becomes. At the same time, the screen tower is located, if possible, near the highway and advertising is displayed on the rear of the tower. This is desirable if practicable. In fact, the general design of the theater is governed to a large extent by the design of the screen.

Most of the drive-in theaters built in the past have used a motion picture screen 30 X 40 ft in size, and have had about 10 ramps. This size screen has proved to be quite satisfactory for this number of ramps. If additional ramps are required, the width of the picture image should be increased 5 ft for each additional ramp.

What are the factors to be considered in obtaining best projection results?

Best projection results may be obtained by utilizing the latest type of projection lenses which are treated lenses of *f.2* speed. In view of the fact that up to the present time projector mechanisms have not accommodated lenses of this type with the focal length in excess of 5 in., it is desirable to lay out the theater in such a way that the projection room shall be within the range of the screen which will permit the use of the treated *f.2* lenses for the particular picture image size selected.

As a result of experience to date for drive-in theaters with a car capacity up to 600, projection equipment consisting of double-shutter projector mechanisms, treated *f.2* lenses, high-intensity positive condenser-type arc lamps operating at 125 amp, or simplified high-intensity arc lamps using metal mirrors and operating at approximately 70 amp, are recommended. For larger theaters, the use of the high-intensity lamp houses with quartz condensers is more desirable.

What about the handling of electrical wiring?

In drive-in theaters, electrical wiring requires special treatment not necessary in enclosed theaters. It is quite important that all electrical wiring be mounted on the ceiling and walls above the ground level of the projection room so as to eliminate the possibility of water getting into the conduit and causing short circuits. Amplifiers, sound change-overs, etc., should be mounted on special insulated backing to eliminate the possibility of short circuits and grounds from

moisture prevalent in most drive-in theaters. All underground wiring should be Parkway Cable or lead covered and all joints should be insulated with tar. In fact, we recommend the use of conduit wherever possible with the same treatment.

Motor generator sets or rectifiers should be mounted in a room on a level above the ground to guard against damage from poor drainage.

What types of sound systems are most suitable for drive-in theaters?

The success of the drive-in obviously stands or falls on the quality of its sound. A great deal has been learned about the type of sound systems most satisfactory for this type of theater. In certain localities it has been found that the use of large loudspeakers at the screen was not satisfactory owing to the proximity of houses whose occupants were disturbed by the "spill-over" of reproduced sound. Where the site for a drive-in theater has been selected and this condition exists, the only satisfactory alternative is the use of individual loudspeakers. Up to the present time, 2 general types of individual loudspeakers have been used; one of which is permanently mounted so that occupants of cars can listen to them through open windows, and the other is hung on the door of the car.

In the selection of either the large loudspeaker or the individual loudspeaker, it is of course important that a type be utilized that will reproduce not only sound of sufficiently good quality, which is quite a problem in the case of the individual speakers, but also properly distribute the sound over the area required. It is anticipated that immediately after the war new and improved types of loudspeakers will be introduced for drive-in theaters which will assure the patrons perfect enjoyment of the show and eliminate the possibility of spill-over sound annoyance in communities where houses closely adjoin the theater.

What type of screen is most practical for drive-in theaters?

Up to the present time most drive-in theaters have utilized motion picture screens consisting of flat white paint on a wooden surface. The use of this type of screen has resulted from the fact that it is exposed to varying weather conditions. It is relatively simple after the screen has become streaked from rain storms to repaint it during the season. It is hoped that in the post-war period a plastic screen, which will permit a higher quality of projection, will be made available, and one which will be impervious to weather conditions to which drive-in theaters are subjected. This screen will be of a type which can be easily restored by the use of a chemical cleaner.

I have given you a brief outline of the many factors which must be given careful consideration by the planner of a drive-in theater if his venture is to be a successful one.

There appears to be every indication that in the years immediately following the war at least one drive-in theater will be constructed in every good-size town and city in the country.

Proof that the drive-in theater idea has come of age is evidenced by the attitude of the major film exchanges. Until approximately a year ago, a drive-in theater had to accept whatever pictures it could secure. Now we find that the exchanges have acknowledged their success and are supplying these theaters with films of greater entertainment value. The fact that they can secure these pictures insures, to a considerable degree, the continued success of the drive-in theater.

57th SEMI-ANNUAL TECHNICAL CONFERENCE OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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HOLLYWOOD-ROOSEVELT HOTEL
HOLLYWOOD, CALIFORNIA
MAY 14-18, 1945

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HOTEL RESERVATIONS AND RATES

The Hollywood-Roosevelt Hotel management extends the following per diem room rates, European Plan, to SMPE members and guests attending the Fifty-Seventh Technical Conference:

Room with bath, one person.....	\$4.40
Room with bath, two persons, double bed.....	5.50
Room with bath, two persons, twin beds.....	6.60-7.70

Note: There will be no parlor suites available at the hotel during the conference dates.

Special Notice

Owing to the acute housing situation in Hollywood, the hotel management can assign the conference only a limited number of rooms for Eastern and Midwestern members attending this Conference. Therefore *no room reservation cards* will be mailed to the membership as heretofore. Accordingly, you are requested to make room reservations *direct* with Stewart H. Hathaway, Manager of the Hollywood-Roosevelt Hotel, Hollywood, California, not later than April 10. *No rooms will be assured or guaranteed at this hotel unless confirmed by Mr. Hathaway which are subject to cancellation prior to May 10.*

Your Conference Chairman has arranged with the Mark Hopkins Hotel management in San Francisco, California, to provide accommodations for members who will visit this city while on the West Coast. Accordingly, reservations should be made *direct* with R. E. Goldsworthy, Manager of this hotel, at least 2 weeks in advance of your arrival in San Francisco. When making reservations, advise the management that you are a member of the SMPE.

RAILROAD AND PULLMAN ACCOMMODATIONS

Eastern and Midwestern members of the Society who are contemplating attending the Conference in Hollywood should consult their local railroad passenger agent regarding train schedules, rates, stopover privileges, and Pullman accommodations at least 30 days prior to leaving, otherwise no accommodations may be available.

REGISTRATION

The Conference registration headquarters will be located on the mezzanine floor of the hotel near the Studio Lounge where all business and technical sessions will be held during the Conference. Members and guests are expected to register. The fee is used to help defray Conference expenses.

TECHNICAL PAPERS

Members and others who are contemplating the presentation of papers can greatly assist the Papers Committee in their early program assembly, and scheduling in the final program, by mailing in the title of paper, name of author, and a *complete manuscript* not later than *April 20* to the West or East Coast chairman of the Papers Committee, or to the Society's New York office. Only by having

your cooperation can the 1945 Spring Conference program be released for publication and distribution to members in Hollywood and vicinity prior to the Conference.

SOCIAL FUNCTIONS

The usual Conference Get-Together Luncheon will be held in the Terrace Room of the hotel on Monday, May 14, at 12:30 p.m. The luncheon program will be announced later.

Members in Hollywood and vicinity will be solicited by a letter from S. P. Solow, Secretary of the Pacific Coast Section, to send remittances to him for Conference registration fee and luncheon tickets. Checks or money orders should be made payable to W. C. Kunzmann, Convention Vice-President, and not to the Society.

INFORMAL DINNER-DANCE

The Fifty-Seventh Semi-Annual Dinner-Dance and social get-together of the conference will be held in the California Room of the hotel on Wednesday evening, May 16, at 8:30 p.m.

A social hour with your Board of Governors will precede the Dinner-Dance between 7:30 p.m. and 8:30 p.m. in the Terrace Room. (Refreshments)

Table reservations may be made and tickets procured for the Dinner-Dance during the week of May 6 from W. C. Kunzmann, Convention Vice-President, Hollywood-Roosevelt Hotel, or at the registration headquarters not later than noon on *May 15*. All checks or money orders should be made payable to W. C. Kunzmann, Convention Vice-President, and not to the Society.

Because of strict food rationing and a shortage of hotel labor, your committee must know in advance of the Luncheon and Dinner-Dance the number of persons attending these functions in order to make the necessary hotel arrangements. Therefore your cooperation is solicited.

LADIES' REGISTRATION

There will be no ladies' reception committee or hostess during the Fifty-Seventh Technical Conference. However, all ladies are requested to register at the registration desk to receive identification cards for admittance to the *deluxe* motion picture theaters on Hollywood Boulevard in the vicinity of the hotel. Ladies are welcome to attend the Luncheon on May 14 and the Dinner-Dance on May 16.

MOTION PICTURES AND RECREATIONAL PROGRAM

The Fifty-Seventh Technical Conference recreational program will be announced later when arrangements have been completed by the local committee.

Conference identification cards issued only to registered members and guests will be honored through the courtesy of the following *deluxe* motion picture theaters on Hollywood Boulevard:

FOX WEST COAST GRAUMAN'S CHINESE AND EGYPTIAN
HOLLYWOOD PARAMOUNT
HOLLYWOOD PANTAGES
WARNER'S HOLLYWOOD THEATRE

*Tentative Program**Monday, May 14, 1945***Open Morning**

- 10:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Luncheon tickets.
12:30 p.m. *Terrace Room:* SMPE Get-Together Luncheon. (Speakers)
2:00 p.m. *Studio Lounge:* Opening Conference.
Business and Technical Session.
8:00 p.m. *Studio Lounge:* Evening Session.

*Tuesday, May 15, 1945***Open Morning**

- 10:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Dinner-Dance tickets.
2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.

Wednesday, May 16, 1945

- 9:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Dinner-Dance tickets.
9:30 a.m. *Studio Lounge:* Morning Session.

Open Afternoon.

- Note:* Registration headquarters will be open on the afternoon of this date for those desiring to make final arrangements for Dinner-Dance tables and accommodations.
- 7:30 p.m. *Terrace Room:* A social hour with your Board of Governors preceding the Dinner-Dance. (Refreshments)
8:30 p.m. *California Room:* The Fifty-Seventh Semi-Annual Dinner-Dance and social get-together. Dancing and entertainment.

*Thursday, May 17, 1945***Open Morning.**

- 2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.

*Friday, May 18, 1945***Open Morning**

- 2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.
Adjournment of the Fifty-Seventh Semi-Annual Technical Conference.

IMPORTANT

This semi-annual meeting of the Society was planned several months ago, and the Convention Vice-President and various committees on arrangements had formulated the program outlined on these pages prior to the issuance of the recent order by the Office of Defense Transportation requiring formal governmental approval. Likewise, the pages of this issue of the Journal were prepared in advance.

Inasmuch as the War Committee on Conventions may not act on our application for some time, the original plans for the 57th Semi-Annual Technical Conference are being followed, subject to subsequent cancellation if necessary.

W. C. Kunzmann
Convention Vice-President

SOCIETY ANNOUNCEMENTS

ATLANTIC COAST SECTION MEETING

The subject of sound quality measurement was discussed at the meeting of the Atlantic Coast Section on December 13, 1944, at the Hotel Pennsylvania. Dr. E. Meschter, research physicist, Photo Products Department, E. I. du Pont de Nemours, Parlin, N. J., spoke on practical aspects of intermodulation tests.

Dr. Meschter reviewed the theoretical basis for such tests and explained some of the practical precautions necessary in both recording and reproducing the test tracks. He pointed out that intermodulation tests may be used not only to determine the best processing conditions for a particular combination of negative and positive film emulsions, but that they may also be used to determine the best characteristic curve from a variety of emulsions similar in other respects but differing in the shape of the H and D curve.

Fred G. Albin of RCA, formerly of Samuel Goldwyn Studios, Hollywood, gave a résumé of some work which he had done in investigating the cause of erratic results in intermodulation tests. He pointed out that the conventional test may be affected by negative development in which the "directional effect" or lack of sufficient agitation of the developer is appreciable. In such cases Mr. Albin found that a more representative test was obtained by using a low frequency between zero and 200 cycles, depending upon the developing conditions.

The meeting was opened with a showing of the 16-mm motion picture, "The Diode."

EMPLOYMENT SERVICE

POSITIONS OPEN

The following positions of interest to SMPE members were available at JOURNAL press time. Applicants should apply *direct* to company at address given.

Young man with several years' experience in Motion Picture Camera and Projector design. Must have mechanical background with a knowledge of motion picture industry requirements. Write or telephone for interview. Akeley Camera, Inc., 175 Varick St., New York 14, N. Y. WALKER 5-7954.

Optical engineer's assistant. Acquainted with optical laboratory routine, ray tracing and similar problems in related scientific fields. Reply to Optical Engineering Department, DeVry Corporation, 1111 Armitage Ave., Chicago 14, Ill.

Notices from business organizations for technical personnel and from members of the Society desiring technical positions which are received before the 15th of the month will appear in the JOURNAL of the following month. Notices should be brief and must give an address for *direct* reply. The Society reserves the right both to edit or reject any notice submitted for publication.

We are grieved to announce the deaths of George P. Bourgeois, Associate member of the Society, on October 9, 1944, Raymond B. Murray, Active member, on January 3, 1945, and A. J. Seeley, Active member.

**MEMBERS OF THE SOCIETY
LOST IN THE SERVICE OF
THEIR COUNTRY**

FRANKLIN C. GILBERT

ISRAEL H. TILLES

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Industrial Arts Index available in public libraries.

JOURNAL
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**JOHN I. CRABTREE, Kodak Park, Rochester 4, N. Y.

**CHARLES R. DAILY, 5451 Marathon St., Hollywood 38.

*EDWARD M. HONAN, 6601 Romaine St., Hollywood 38.

*CLYDE R. KEITH, 233 Broadway, New York 7.

*G. T. LORANCE, 92 Gold St., New York 7.

**PETER MOLE, 941 N. Sycamore Ave., Hollywood.

*HOLLIS W. MOYSE, 6656 Santa Monica Blvd., Hollywood.

**WILLIAM A. MUELLER, 4000 W. Olive Ave., Burbank, Calif.

*EARL I. SPONABLE, 460 West 54th St., New York 19.

**REEVE O. STROCK, 111 Eighth Ave., New York 11.

*WALLACE V. WOLFE, 1016 N. Sycamore St., Hollywood.

*Term expires December 31, 1945. †Chairman, Pacific Coast Section.

**Term expires December 31, 1946. ‡Chairman, Atlantic Coast Section.

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THE ABC OF PHOTOGRAPHIC SOUND RECORDING*

EDWARD W. KELLOGG**

Summary.—Suggestion has been made that a paper be prepared outlining the broad principles of photographic sound recording as practiced for motion pictures. If it is attempted to make such a paper deal with anything like adequacy with the many phases of this complex art, it would be nothing short of a book. However, it appears possible to present in reasonably brief space the essential principles of photographic sound recording systems and to supplement this with a bibliography which will at least give the reader a start in studying any special phases of the question.

It is hoped that a paper of this type may serve a useful purpose in helping those who are suddenly confronted with the necessity of working in this field to gain a preliminary picture of what is involved in photographic sound recording, so that they can with less difficulty read the papers which discuss the various special problems.

Description of a Sound Track.—A photographic sound record is designed to be used with a lamp and a photocell,¹ which has the property of passing electric current in proportion to the intensity of the light which strikes its cathode plate. The sound track must provide the means for producing fluctuations in the light transmitted to the photocell, which correspond with adequate fidelity to the variations in sound pressure which originally reached the microphone. In the case of 35-mm motion picture film a space has been provided for the sound track by narrowing the picture, while in the case of 16-mm film the space has been provided by omitting one row of sprocket holes.

For reproduction, the film is carried past an optical system such as shown in Fig. 1. Light from the lamp is restricted by a narrow slit at *S*, an image of which is produced on the film at *F* by the objective lens *O*. The condensing lens *C*, which is of such focal length as to produce an image of the lamp filament within the aperture of lens *O*,

* Presented Apr. 19, 1944, at the Technical Conference in New York.

** RCA Victor Division of Radio Corporation of America, Indianapolis, Ind.

causes the slit to appear illuminated throughout its length.² The photocell is placed back of the film so as to receive as much of the light reaching the film at *I* as is not obstructed by the developed silver in the track.

We may speak of the image of the slit on the film as "a line of light," and ideally it should be a line for perfect reproduction, but in order to pass a reasonable quantity of light to the photocell it is given a width of the order of 0.001 in. while its length is normally about 0.084 in. for 35-mm systems, and 0.071 in.* for 16-mm systems.³ The mechanical requirements are that the film shall move at the correct uniform rate through this light beam, in a direction at right angles to

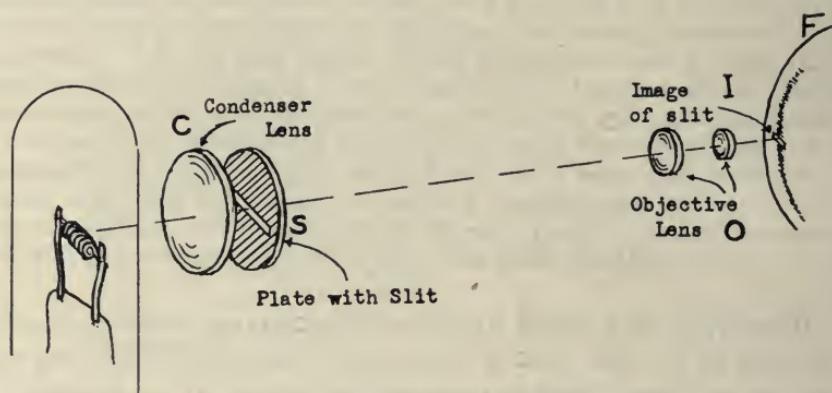


FIG. 1. Reproducing optical system.

the slit image, that it be maintained in the plane of sharp focus, and shall not have any sidewise motion or weaving beyond certain small limits or "tolerances."

A part of the light which strikes the film at *F* is absorbed by the silver in the emulsion at that point, and the remainder passes through to the photocell, the electrical output of which is amplified and applied to loudspeakers. As the film carrying the sound track passes through this light beam, it absorbs varying amounts of the incident light. The light modulated in this manner determines the sound waves radiated from the loudspeakers.

The photocell current depends on the *total* quantity of light reaching the cathode. If the correct fraction of the light is absorbed by the

* Supersedes previous standard of 0.074 in.

silver image, the desired result is achieved whether it is absorbed by a uniform gray deposit across the entire track width, or by rendering certain portions of the track completely black. We thus have 2 types of track, as shown in Figs. 2 and 3, one of which is known as the "variable-density" system, and is composed of various shades of gray, the density of the silver deposit being uniform across the track; the second type is known as the "variable-width" or "variable-area" system, the track being divided into essentially black-and-white areas. The boundary between these areas is a picture of the sound wave.^{4,5}

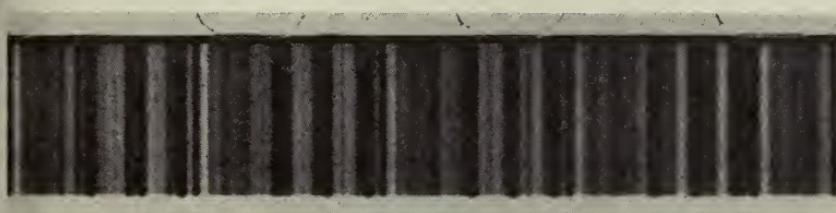


FIG. 2. Variable-density sound track.

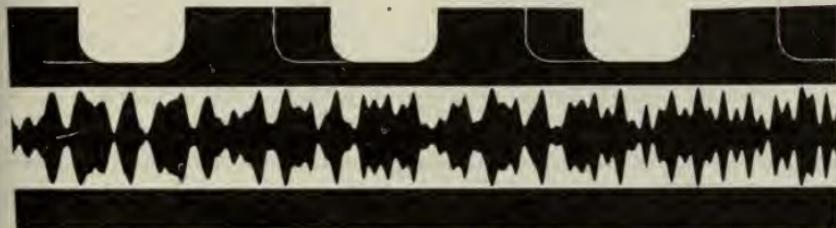


FIG. 3. Variable-area sound track.

It is obvious that the recording of a variable-area track requires that the length of the illuminated portion of the slit shall be varied from instant to instant in accordance with the sound pressures in the original sound, while the variable-density recording requires that means be provided for varying the intensity of the exposing light, the illumination at any instant being uniform throughout the slit length.

Sound consists in variations of air pressure above and below the average atmospheric pressure. The electric currents which are produced by the microphone and are used for transmission of the sound,

may be alternating, but the exposing light cannot reverse sign but must consist of a certain mean value of light on which the fluctuations are superimposed. Similarly the light which reaches the photocell consists in a steady value on which fluctuations are superimposed, and the same is true of the current from the photocell. The maximum light which can reach the photocell is that which would pass through clear film. The sound track must cut the average light to 50 per cent or less of this maximum, thus permitting upward and downward variations between zero and 100 per cent.

Recording Variable-Density Tracks.—Making a variable-density record calls for either employing a lamp whose brightness can be varied at audio frequency, or employing some optical device by which various fractions of the lamp output can be absorbed or diverted. Even under optimum conditions it has not been found possible to

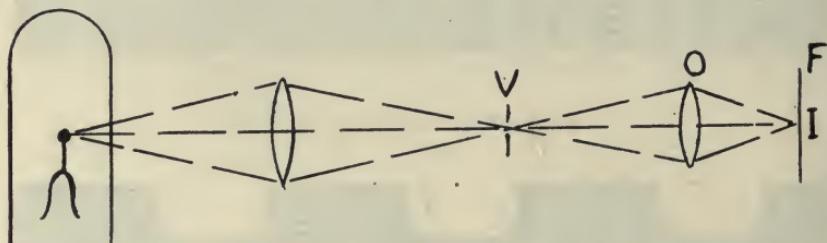


FIG. 4. General optical arrangement for light-valve recording.

change the brightness of incandescent filaments with the required rapidity for sound recording; hence all variable-intensity light source recording has been done with lamps of the gas-discharge type.

Mercury lamps were among the first to be used,^{6a} but under the conditions which give the extreme high brilliancy⁷ of which mercury arcs are capable, the luminosity does not fall rapidly enough when the current decreases for satisfactory modulation, while at low pressures or intensities the advantage of mercury vapor over other gases is not great.

The most successful glow lamp is known as the "Aeolight" and was developed by the Theodore Case Laboratories at Auburn, N. Y.⁶ It has been widely used in Fox Movietone newsreel equipment, and employs a hot cathode and a mixture of permanent gases, thus is much less affected by external temperature than any mercury vapor lamp.

Nitrobenzol has the property of rotating the plane of polarization

of light through an angle which increases with the strength of a transverse electric field. If a cell of nitrobenzol is placed between crossed polarizing prisms, no light is transmitted until an electric field is applied to the nitrobenzol, and the amount of light increases with the sine of the angle of rotation up to the point of 90 degrees rotation.

The CaroJus Cell, or Kerr Cell,⁸ as this device is called, is one of the fastest known means of modulating light, so there is no question about getting adequate high-frequency response. However, the high voltage required, the discoloration of the liquid, geometrical limitations which restrict the amount of transmitted light and, most of all, the non-

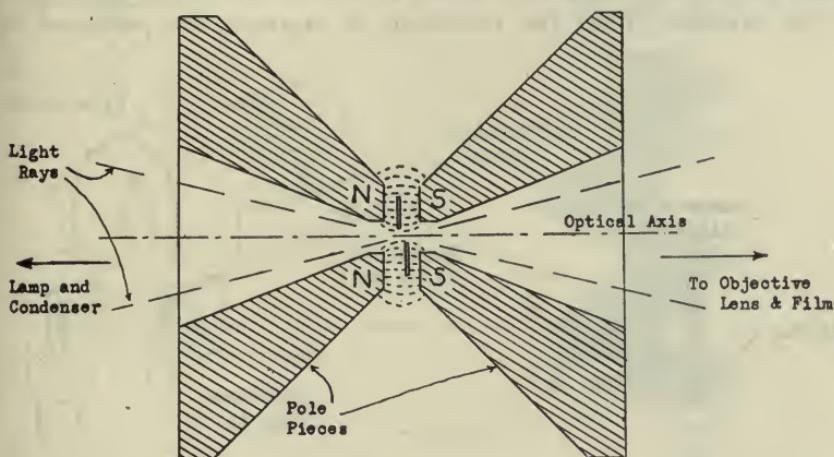


FIG. 5. Light-valve ribbon and pole piece arrangement—section at right angles to ribbons.

linearity of the characteristic, have contributed to the abandonment of the Kerr Cell as a sound recording device.

Starting with a constant source of light such as an incandescent lamp, the exposure of the film may be modulated by either varying the size of an opening through which the light must pass, or by employing a reflecting galvanometer. The manner of employing a reflecting galvanometer for making variable-density records can best be explained after description of the variable-area recording system.

The variable-sized aperture method is represented by the Western Electric "Light Valve."⁹ Fig. 4 shows the general optical arrangements, with the valve or variable-width slit indicated at *V*. The condensing lens system concentrates light on the valve, and the light which passes through the opening is focused on the film at *I* by ob-

jective lens O . The variable-sized slit is a narrow opening between the edges of 2 stretched metal ribbons which carry the recording current in one direction through the upper ribbon and back through the lower ribbon. A strong magnetic field is provided, parallel to the optical axis, and the audio currents cause the ribbons to approach and recede from each other, thus widening and narrowing the slit between. Fig. 5 illustrates the arrangement of ribbons and magnet pole pieces. In order that the ribbons may not actually hit they are slightly displaced axially, so that they are in different planes.

The slit is sharply focused on the film. It will be noted that the image on the film varies in width in accordance with the movements of the ribbons. Thus the variations in exposure are produced by

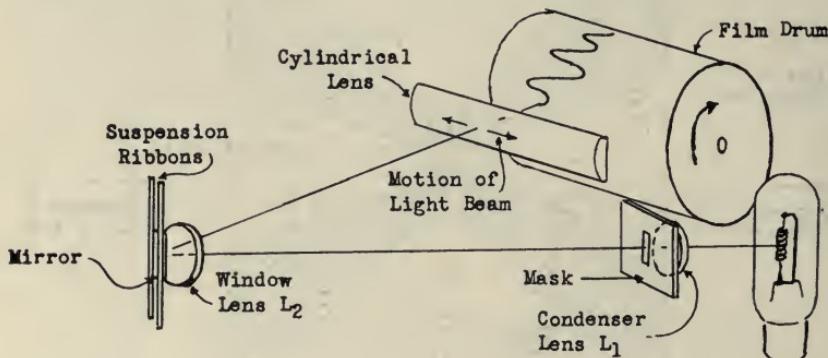


FIG. 6. Optical system of Duddell oscillograph.

changes in the time during which the film is passing through the illuminated spot, and not by variations in the intensity within the spot. The difference between varying the intensity and varying the time of exposure must be taken into account in any complete analysis of the performance of variable-density systems.¹⁰

Modulation for Variable-Area Recording—Variable-area recording systems may be considered to be an outgrowth of the Duddell oscillograph,¹¹ in which a tiny galvanometer swings a spot of light back and forth across a moving film and traces a picture of the wave shapes of the electric currents sent through the galvanometer. Fig. 6 shows the essential optical arrangements of the oscillograph. The cylindrical lens near the film serves to make the light spot smaller and more intense, and serves to confine the light reaching the film to a narrow line, so that a mask with a very narrow slit is not necessary. In the oscillo-

graph, pains are taken to make the light spot small in both directions so as to trace a sharp line as shown at *A* in Fig. 7. This is done by making the light source itself small.

By using a larger light source, we can elongate the light spot on the film until its length exceeds its total amplitude of travel. The oscillograph would then make a record like that shown at *B* in Fig. 7, in which the wave shape trace has been broadened to a black stripe,

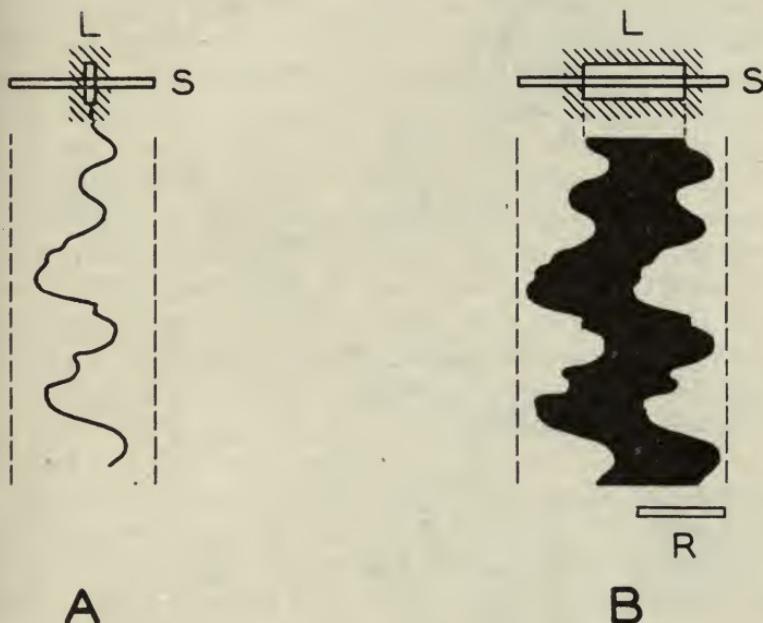


FIG. 7. Evolution of variable-area sound track from oscilloscope. *A*—Standard oscilloscope recording; *B*—Recording by oscilloscope with wide light spot; *L*, *L*—Light spots; *R*—Light spot by which sound would be reproduced from track *B*; *S*, *S*—Slits close to film or equivalent effect produced by short focus cylindrical lenses.

whose edges are pictures of the wave shape. Such an oscillogram can be used as a variable-width sound record by simply scanning either edge by itself.

The optical system used in variable-area sound recording, illustrated in Fig. 8, is essentially the same as that of the oscilloscope except that instead of throwing the light spot from the galvanometer directly on the film, it is projected on a slit-plate of mask *M*, in which there is a narrow slit *S*, and the slit is imaged on the film in reduced

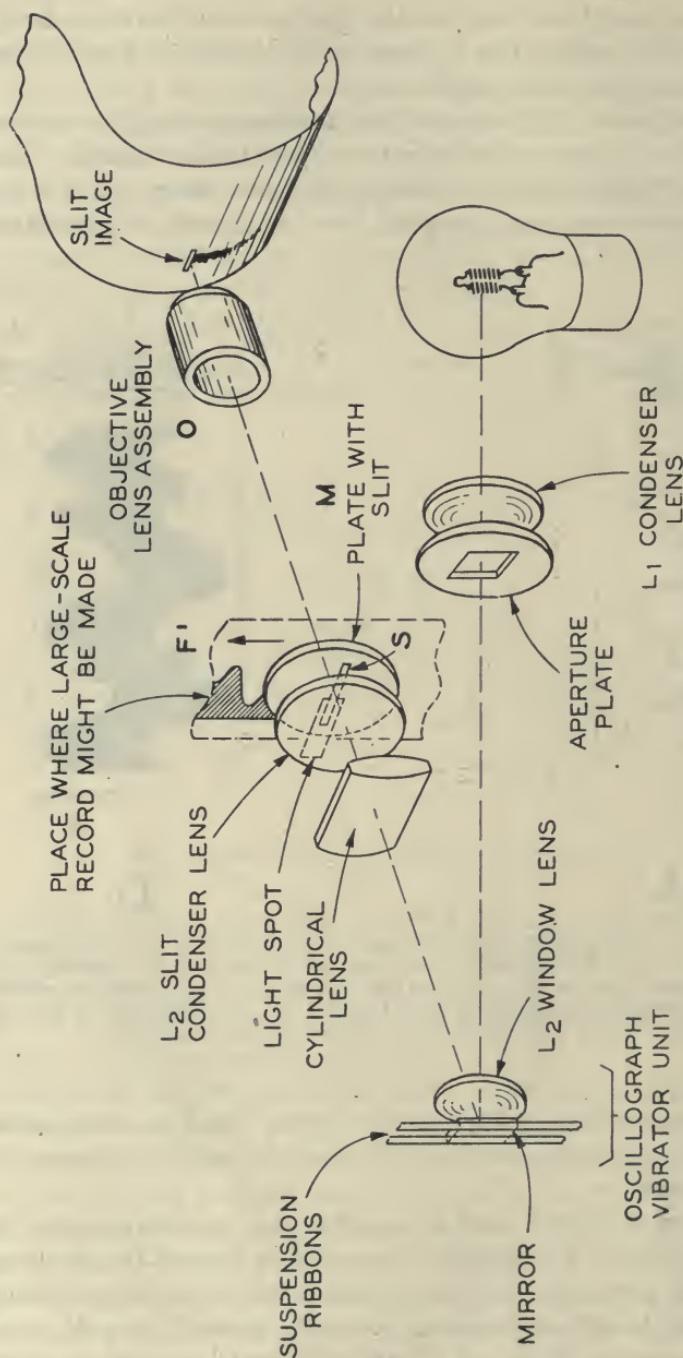


FIG. 8. Original Photophone variable-area recording system.

dimensions by an objective lens O . If a film were pulled through the device, directly behind the slit, as shown dotted at F' , we would obtain a large record of the wave shape. Since the purpose of the recording optical system shown in Fig. 8 is to produce a track like that shown at Fig. 10A, only one end of the light spot falls within the slit length, the other end being masked off.

The ordinary oscilloscope has been developed to produce rather large-scale traces of wave shapes. The sound track requires that the wave trace be of microscopic dimensions. The system in which the modulated light is thrown on a slit of convenient size and then a reduced image of the slit formed on the film, lends itself to production of small-scale images of finer quality than could readily be obtained by the direct system, particularly since lenses of extraordinarily high resolving power have been developed for microscope objectives.^{12c}

About 1932 the arrangement in which the light spot moves parallel to the slit was abandoned in favor of one in which it moves transversely to the slit.^{4a} This is illustrated in Fig. 9. The present arrangement offers advantages on the score of sensitivity, since by throwing on the plane of the slit a triangle whose edge makes an acute angle of intersection with the slit, a smaller movement of the galvanometer suffices to change the length of the illuminated portion of the slit from zero to 100 per cent.

Another important advantage is that the system becomes readily adaptable to making various types of track.^{4b} This is illustrated in Fig. 10. With a single sloping edge intersecting the slit, we can get the original unilateral track (Fig. 10B). If the light spot is a triangle with the vertex normally at the middle of the slit, we get a symmetrical track (Fig. 10C). Two triangles, one on each side, with vertices pointed in opposite directions, produce a push-pull track (Figs. 10D or 10E). If the triangles are so positioned that their vertices cross the slit simultaneously, we can produce a Class B push-pull track (Fig. 10F). Push-pull and Class B tracks are discussed in the next section.

In all cases the triangular opening does not stop at the base of the triangle, but an additional rectangular area is provided, adjacent to the base of the triangle. This prevents a very objectionable distortion which would otherwise occur whenever, because of overload, the base of the triangle crosses the slit. By putting in a mask which produces a black triangle on a white background we can make a direct positive ready to play back without resorting to a printing operation.¹³ This is illustrated at G, Fig. 10, as applied to a Class B track.

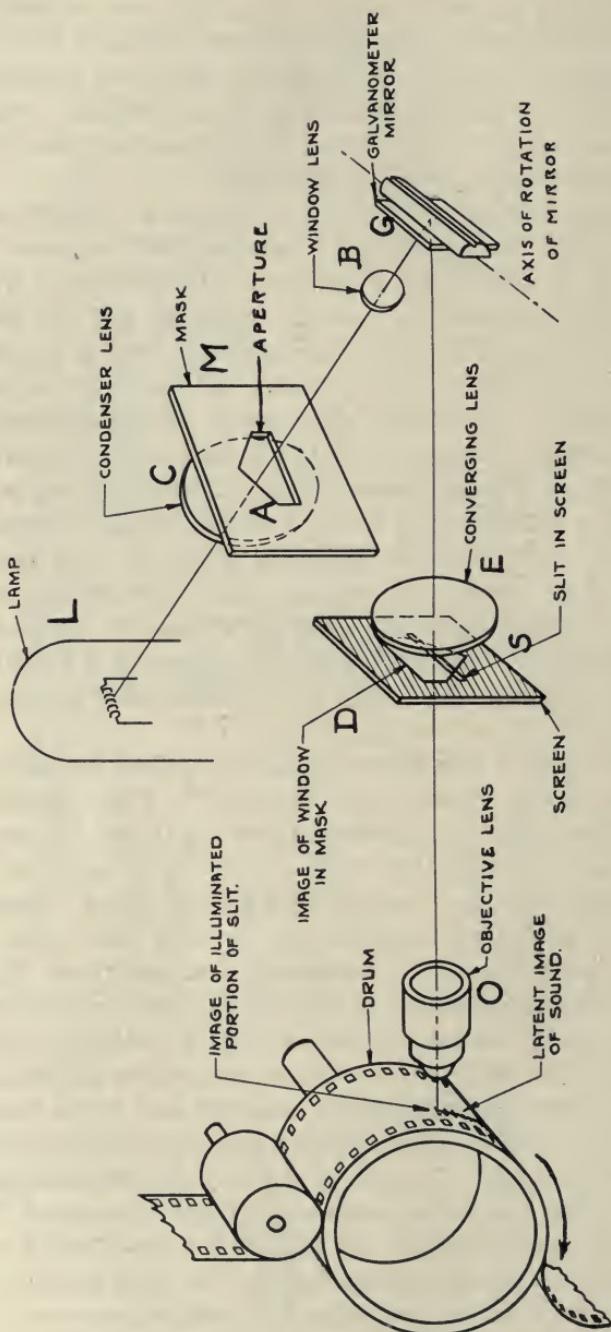


FIG. 9. Elements of optical recording system.

If the light source (in this case a single horizontal helix) is uniform in brightness from top to bottom, a horizontal edge suitably located between the condenser and the galvanometer casts a shadow on the plane of the slit which varies at uniform rate from zero to 100 per cent brightness. The movements of the galvanometer move this graded shadow or penumbra up and down, and the intensity of the slit image on the film varies in accordance with the galvanometer deflection. This provides for making variable-density records.¹⁴

Push-Pull Tracks.—If the track is divided into 2 equal strips and the light is modulated oppositely on the 2 sides of the middle, it may be reproduced by a system in which the light that passes through the film is picked up by 2 photocells, which are oppositely connected as shown in Fig. 11. Several types of distortion are substantially reduced by applying a push-pull system, especially those which produce even harmonics and rectification effects.¹⁵

Push-pull systems have been widely used for making original recordings where the utmost in quality is justified even at the cost of greater complication in the recording and reproducing equipment. Many of the push-pull systems which have been used in recording studios employ double-width track. This results in an improvement in the ratio of useful sound to ground noise.

Mention has already been made of the Class *B* track,¹⁶ illustrated in Fig. 10. The left side of the track carries only the negative halves of the waves, and the right-hand side the positive halves. Careful adjustments are required in which the characteristics of the film emulsion and developer have to be taken into account in order to balance and adjust the system so that no distortion occurs at the point of transition between positive and negative half-cycles. A hairline extension of the vertex of the triangle makes the adjustment for transition less critical.

The Class *B* track is inherently the freest from ground noise of any of the known types of photographic sound record. For this reason it is finding much use for making original recordings (for subsequent rerecording to standard track). The ground noise advantage of the Class *B* track is carried still farther if it is recorded as a direct positive.¹³

A modification known as the "*A-B*" variable-area track^{16d} has been used to a limited extent, in which the masks are so shaped that very low amplitudes are recorded Class *A* while higher amplitudes are recorded Class *B*. The *A-B* system is somewhat less critical to ad-

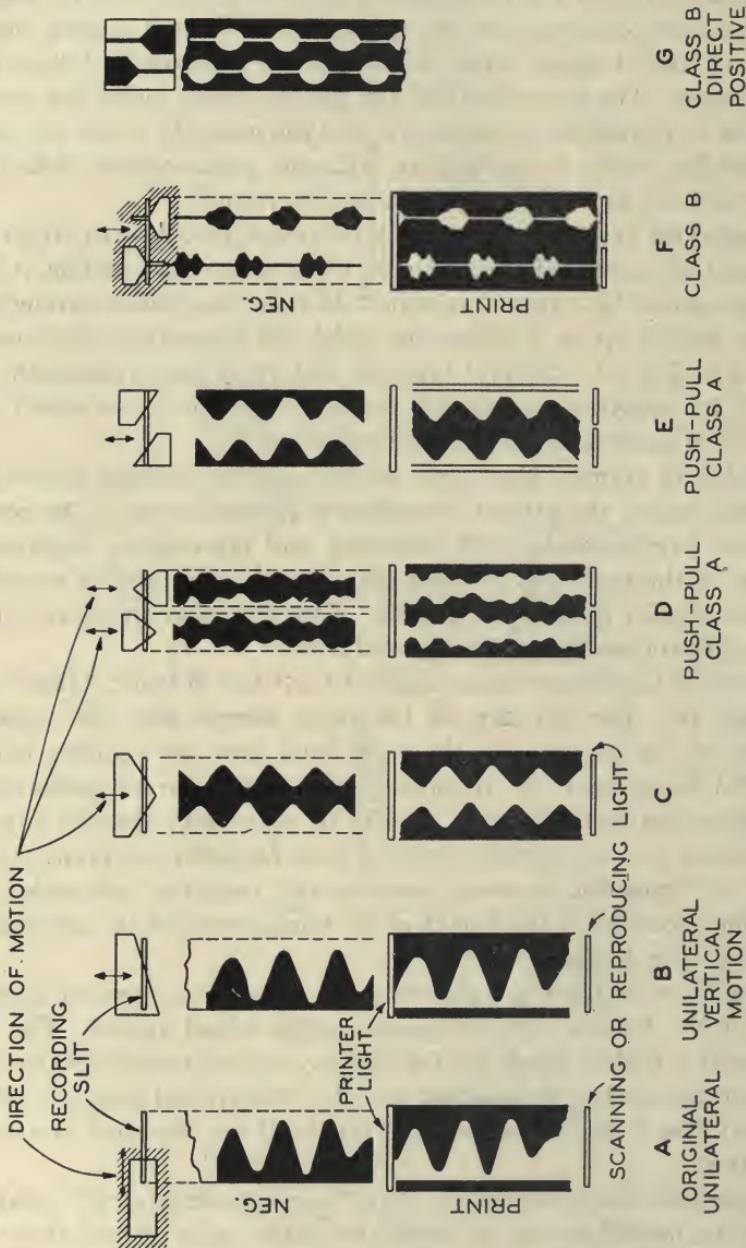


FIG. 10. Types of variable-area sound tracks.

justment, but does not go as far in the reduction of ground noise as the Class *B* system.

Ground Noise Reduction.¹⁷—While there are various sources of background noise (such as photocell hiss, fluctuations in the brightness of the reproducing lamp, and hum resulting from circuit causes) which are not caused by the film itself, these can, in a well-designed system, be made very small compared with the noise which is caused by the moving film. It is obviously important that fluctuations in the sources of illumination used for recording and printing shall be prevented, and that all causes of nonuniformity in development be minimized.¹⁸ However, when all these are done there are still variations in the opacity of exposed film. These variations are usually referred to as "graininess."

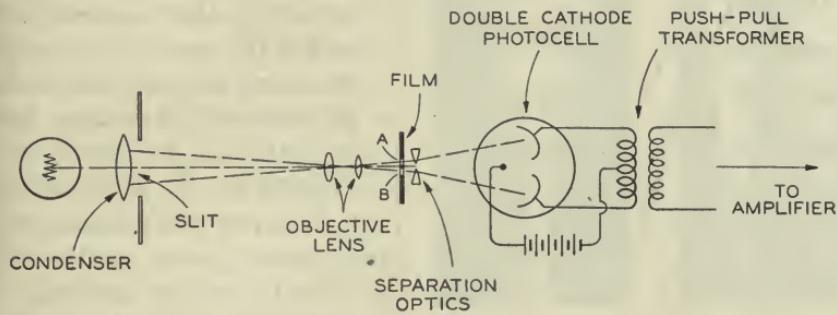


FIG. 11. Arrangements for reproducing push-pull track, simplified circuit. (Commercial circuits are adapted to switching between push-pull and standard, and to adjusting photocell voltages to give balance.)

The subject of film graininess and the factors which affect it has received a great deal of theoretical and experimental study, and the excellent papers listed in the bibliography are commended to the reader's attention.¹⁹ Graininess gives rise in the sound reproducing system, to a soft hiss. Although graininess is caused by imperfect distribution of the film grains rather than a matter of light obstruction by the individual grains, it is generally true that whatever results in fine grains also gives reduced graininess, as shown in Fig. 12, which is reproduced from the paper by Sandvik, Hall, and Grimwood.^{19d} The absolute level of noise resulting from graininess increases at first with the silver deposit and reaches a maximum when approximately half of the light is absorbed. Thereafter it falls continuously because there is less light to modulate. Hence in variable-

density systems graininess noise is reduced by making the sound track as dark as is compatible with providing the required useful light modulation.

The remainder of the film ground noise results from dirt and abrasions on the film surface. Dust particles which settle on the film while it is wet cause specks that are very difficult to remove. For this reason, well-run laboratories do all of their film handling in an atmosphere which is as nearly dust-free as modern air conditioning can make it.²⁰ Developing, fixing, and washing baths are continuously filtered and checked for condition.²¹ In properly de-

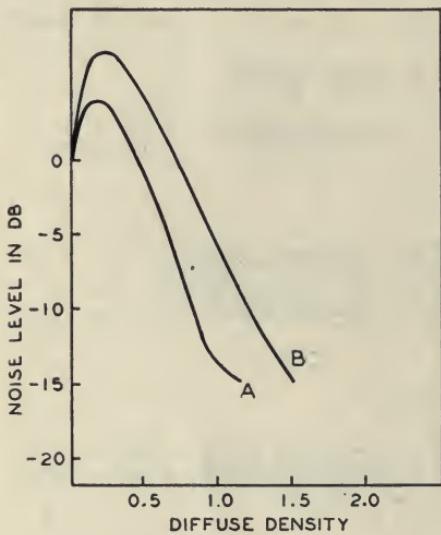
signed cameras, sound recorders, printers, and projectors, all possible precautions are taken to avoid danger of scratching the film, especially within the area of the sound track and picture, but release prints in their circulation from one theater to another inevitably receive some damage.

Probably the greatest cause of ground noise (of the type caused by film abrasion) is slippage between layers of film in take-up magazines. Since projection booths are rarely dust-free, particles of dirt collect on the film and are then rolled in, and cause scratches when there is any slippage.

FIG. 12. Relation between density and noise owing to graininess. Positive film developed (A) in D-16 and (B) in D-89.

It is practically impossible to scratch a clear spot in a dark film, but the least scratch in a clear area has the effect of a black spot.

There is therefore, in variable-area recording, much to gain by avoiding any unnecessary clear area in the prints. This is accomplished by providing a maximum of clear area in the negative. Specks in the clear areas of negatives print out as holes in the dark areas of the prints, but since the sound negatives can usually be fairly well guarded from abuse, the noise attributable to the negative is, in general, much less than that which results from scratches and dirt in the release prints after some use. Moreover, if the specks on the



negative are very small they will not print through as perfectly clear spots in the print, but will be partly fogged in.

In variable-density recordings, the noise from scratches and dirt is minimized by the same measure as was just described as helpful with respect to graininess noise, namely, by reducing the average exposure of the negative during periods of low modulation, which results in a thin negative and a correspondingly dark print.

It is obvious that at full modulation, a variable-area track should transmit on the average approximately 50 per cent of the maximum light, but when the amplitude of the recorded waves falls, a narrower clear area will suffice. It is during times of low modulation that ground noise is most objectionable.

Ground-noise reduction systems used for variable-area recording provide for masking off the unused portion of a sound track area. This may be done by biasing the galvanometer, giving a track such as shown in Fig. 13A, or by use of a shutter²² whose vanes cut off a portion of the recording beam during periods of low modulation, as shown in Fig. 13B. It will be seen in the figure, that the shutter vanes move relatively slowly in and out, following the envelope of the waves recorded by the galvanometer.

Current for actuating the shutter for biasing the galvanometer (*i. e.*, shifting the mean position about which it vibrates) is obtained by applying the audio-frequency voltages to a rectifier and then filtering the rectified current so that at no time does it change rapidly enough to contribute audible noise in the reproduced sound. The design of the filtering system involves a compromise between clipping the tops of the waves in the case of a quick increase in sound amplitude and moving the shutter fast enough so that the motion itself becomes audible. It is likewise essential that the shutter return to the low modulation position with reasonable rapidity upon the

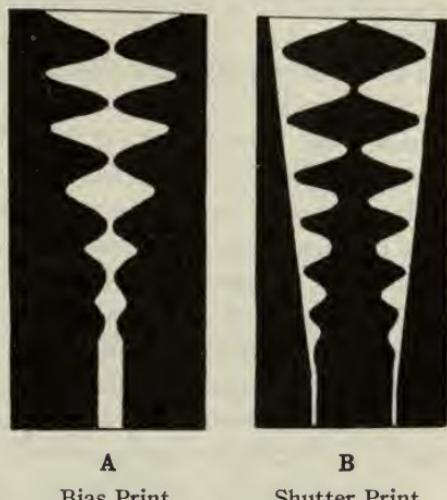


FIG. 13. Sound tracks with ground-noise reduction.

cessation of audio sound; otherwise a certain amount of ground noise becomes audible at the ends of the sounds. It is inevitable in designs of this kind that some differences of opinion would exist as to the optimum, and that considerable variations in design constants will be found in commercial use.

In variable-density systems ground-noise reduction takes the form of making the print darker at times of low modulation. In light-valve systems this is accomplished by bringing the ribbons of the light valves closer together by means of a biasing current,^{17c,e} while in the penumbra system of variable-density recording, using the galvanometer, a separate electromagnetic device similar to the shutter used for variable-area recording moves the vane, the shadow of whose edge constitutes the penumbra.¹⁴

Monitoring.²³—Provision must be made to inform the recordist quickly and continuously of the amplitude of the recording as related to the overload point of the sound track. In variable-area systems this is usually accomplished by throwing a light spot on a screen, the motion of the light spot produced by the vibrations of the galvanometer being a direct indication of the amplitude.^{4b} The system is arranged so that the monitoring card will show bias as well as vibration amplitudes, or else will show the combination or over-all excursions in both directions from the mid-track position. Marks on the card indicate the correct position of the edge of the light spot for zero modulation and maximum permissible modulation.

Card monitoring can be used with the penumbra system of variable-density recording, but in general variable-density monitoring is done by photocell. A portion of the modulated light passing through the recording slit is reflected to a photocell, the output of which is amplified, rectified, and indicated by meter. In order to adjust bias, it is also necessary to be able to measure the continuous or average photocell current; separate provision is made for indicating this.

Inasmuch as the diversion for monitoring purposes of any material fraction of the useful modulated light increases the difficulties of providing adequate exposure, a special reflector was developed for use in the RCA variable-density system, which is practically 100 per cent transparent for blue and violet light, but reflects over 60 per cent of the red light, to which cesium photocells are sensitive, but which plays no part in exposing the recording film.^{23a}

Film Characteristics.—Up to this point our discussion has been practically confined to the optical devices essential to photographic

recording, but a successful final result demands the control of many factors, the most important of which have to do with the behavior of photographic materials.

Everyone who has taken as much interest in pictures, as must be true of all members of the SMPE, knows what is meant by "soft" and by "contrasty" pictures. The soft picture can show many fine gradations of gray, while the contrasty picture may even approach portrayal of the subject in only black-and-white areas. It is obvious that since a variable-width track should ideally consist of clear and

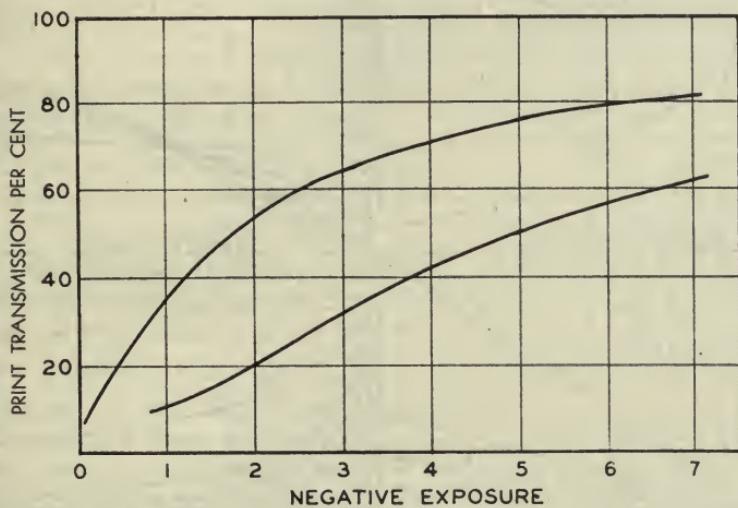


FIG. 14. Relation between negative exposure and print transmission shown on linear scale diagram. The 2 curves correspond to different printing lights with the same negative.

black areas, it is appropriate that choices of film emulsions and development technique be such as to produce high contrast. The high contrast makes it easier to avoid fog in the clear areas and makes the dark areas so black that practically no light gets through. The high contrast also tends to sharpen the borderline.

On the other hand, the variable-density track depends on maintaining all of the intermediate values of gray.²⁴ The characteristics of a photographic operation can be shown in a curve such as shown in Fig. 14, in which the ordinates represent the fraction of the incident light which is transmitted through the print, while the horizontal measurements represent the exposure of the negative, which may be expressed in such units as meter-candle-seconds. Recording

systems for variable-density are, in general, designed to provide an exposure which varies from instant to instant in accordance with the sound pressures to be recorded.

Avoidance of distortion in reproduction requires that there be likewise a linear relation between the light transmitted through the print and the exposure of the negative, or in other words, conditions are sought such as will give a relatively long, straight portion to the characteristic. The negative exposure should be confined to the

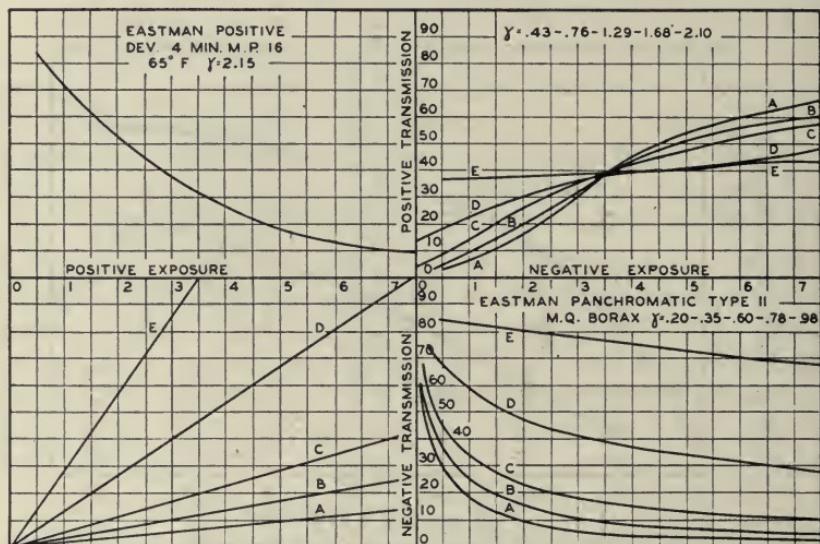


FIG. 15. Method of predicting the relation between print transmission and negative exposure. The several curves are for various negative developments, the appropriate printing light being chosen for each negative. (From a paper by R. F. Nicholson.^{24g})

range for which the characteristic, if plotted as in Fig. 14, is substantially straight.^{9b, 24g} Even though some curvature is tolerated this limits the possible range between maximum and minimum transmission, with the result that for equal amplification it is not possible to get quite as high sound levels from a variable-density film as can be obtained from a fully modulated variable-area film.

The reader will be interested in the method of calculating over-all characteristics illustrated in papers by Nicholson, Jones, MacKenzie, and Mees.²⁴ Fig. 15 is taken from the paper by Nicholson.

H and D Curves and Gamma.^{12b,c,d}—Figs. 14 and 15 showed the transmissions of the prints as functions of the exposures of the

negative. It is desirable to express the characteristics of the negatives and prints separately, and logarithmic scales are desirable for covering large ranges. A method of showing film and development characteristics introduced in 1890 by Hurter and Driffield has become almost universal. The density of the silver image is plotted vertically, against the logarithm of the exposure, plotted horizontally, as shown in Fig. 16. Zero density means 100 per cent transmission. A density of one means 10 per cent transmission, and a density of 2 means that one per cent of the incident light is transmitted. In other words, density D is defined as $\log_{10} 1/T$, where T is the transmission, or fraction of the incident light transmitted through the film. The Hurter and Driffield or "H and D" curve gives certain important information about the film and its development.

Fig. 16 shows the H and D curves for a given film emulsion and several development times. There is usually a substantially straight portion of the curve, between the "toe" and the "shoulder," which covers a major portion of the density range, and the slope of this portion is a measure of the contrast properties of the film, a steep slope corresponding to high contrast. The Greek letter γ ("gamma") has been almost universally employed to designate the slope of this curve.

If the vertical and horizontal log scales are the same, a slope of 45 degrees means a gamma of unity, in which case an increase of one in log exposure produces an increase of one in density, or reduces transmission by a factor of 10, or in other words, 10 times the exposure produces one-tenth the transmission, 4 times the exposure will reduce the transmission to one-quarter, etc. If gamma is 0.5, the transmission varies inversely as the square root of the exposure, or in this case 4 times the exposure will result in only a two-to-one reduction in transmission, while if gamma is 2.0, four times the exposure will cut transmission to one-sixteenth. In short, if E stands for the exposure, T varies as $(1/E)^\gamma$.

If we carry the calculation all the way through from negative exposure to print transmission, we get that T_p varies as $E_n^{\gamma_1 \gamma_2}$.

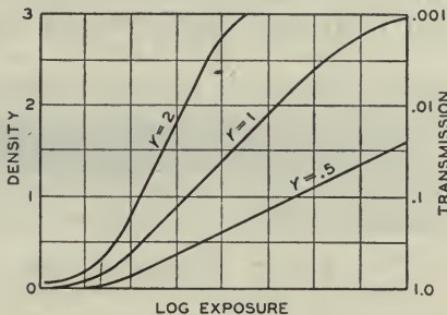


FIG. 16. H and D curves.

This indicates a linear relationship or direct proportionality, provided the product of the negative gamma γ_1 and print gamma γ_2 is unity. Thus for obtaining the linear relationship which is necessary for avoidance of distortion, it is not necessary that both gammas be equal to unity, but a higher print gamma (for example, 2) can be offset by a correspondingly low negative gamma (0.5 in this case), the low contrast in the negative compensating for the high contrast in the print.

The determination of the characteristics of films when subjected to various developments is called "sensitometry." The literature devoted to this subject in the SMPE JOURNALS alone is so extensive that only a fraction is listed here.²⁵

The characteristics of various commercial emulsions are held within quite small variations by the manufacturers,²⁶ but the contrast is strongly affected by the developer formula,²⁹ the time and

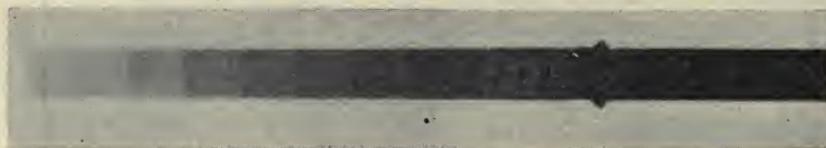


FIG. 17. Example of a sensitometry strip or step tablet.

temperature of development, the agitation of the developer¹⁸ and, in minor degree, by other factors such as drying.²⁷ Satisfactory results with sound recordings cannot be consistently obtained unless the exposures and developments are closely controlled.^{25b}

In the 35-mm film laboratories it is general practice to include a test strip with every recording before it is processed. In order to take account of possible variations in the film itself, the test strip is made from film of the same emulsion batch (indicated by the manufacturer) as the recording which it accompanies. A device known as a "sensitometer"²⁵ subjects a series of small film areas to various exposures covering a wide range, the most commonly used system of gradation being that each block is exposed $\sqrt{2}$ more than the adjacent one, or the exposure doubles every 2 steps. Fig. 17 shows a sensitometry strip or "step-tablet." One or more test prints are made, and the densities of the several steps measured and plotted as in Fig. 16. The curve should fall within specified limits or tolerances, and the correct printing light and print development are

determined on the basis of these tests. The H and D curve for the negative shows whether the negative processing has been normal, but generally the negative must be accepted as it is and the print processing adapted to it.

The relation between density and exposure is not the same for conditions of sound recording as it is for pictures, for it has long been known that the response of a photographic emulsion to exposures is not exactly the same for extreme conditions of high intensity and short duration as it is for lower intensities and longer exposures.¹⁰ Whereas a picture exposure may be commonly $1/50$ sec, a sound track receives its exposure in a period ranging from $1/72,000$ sec to $1/18,000$ sec, depending on the width of the recording slit image. In any exact analysis of sound recording, therefore, it is appropriate to determine the sound track gamma by means of a series of exposures similar to those which the sound track actually receives.^{10,25b,f} On the other hand, the conditions of exposure in the taking of pictures and in the printing of sound track and picture are much alike, ordinary exposure times being in the range 2 to 50 milliseconds.

For measuring the densities of the test strips, numerous forms of "densitometer" have been designed.²⁸ Some of these take into account only the light which passes through the film in substantially straight lines. These measure what is termed "specular density." Others measure all of the transmitted light, or else illuminate the film with light from all possible directions. These measure "diffuse density." It is necessary in specifying the density of a film to state whether specular or diffuse density is meant.²⁸

In picture projection systems and also in sound reproducing systems, most of the transmitted light which is utilized goes straight through the film from one lens system into another, and most of such light as is scattered by the emulsion fails to enter the second lens and is thrown away. On the other hand, in making a contact print, practically all of the light that gets through, whether scattered or not, serves to expose the adjacent print film emulsion. Thus it is appropriate to use diffuse density when calculating conditions for contact printing, while specular density, which takes account of only light which passes straight through the film (plus a small fraction of the scattered light) is used in calculating results which are to be expected in picture projection, sound projection, and in projection printing.

The densities as measured the 2 ways bear fairly consistent rela-

tionships, and for some purposes it suffices to make the measurements on either type of densitometer and apply correction factors where necessary. The holding of exposures and developments in production within previously determined limits requires only that the instruments be capable of giving consistent results. On the other hand, exact analyses require that the sensitometer and densitometer both be of the type appropriate to the sound track conditions.

Film Resolution, Fine-Grain Films, Ultraviolet Recording.—It was found early that the highly sensitive films used for picture negatives do not make the best material for sound recording. The kind of film used for prints has a much finer grain and higher resolution. The difference between making a sound record with the desired minuteness and perfection of form with a coarse and a fine-grain film might be compared to drawing a picture on a surface on which some coarse sand had been dusted as compared with using a smooth paper with a fine pencil. The price for using the finer grain films is that more exposing light must be used. Fortunately this has been possible while still adhering to the highly satisfactory incandescent type of lamp, progress having been greatly helped by improvements in lamps,⁷ and by new film emulsions which in increasing measure combined fine grain and speed.²⁶

One of the most important steps in the direction of producing finer and more accurate images in the sound track was the resort to ultraviolet light.²⁹ Much of the imperfection in photographic resolution is caused by the scattering of light within the emulsion,³⁰ so that the exposure spreads sidewise as well as through the emulsion. Ultraviolet light is rapidly absorbed in the material of the emulsion, with the result that it does not diffuse as far into regions outside the boundaries of the areas actually exposed. The low penetration also prevents any impairment of the image by reflections from the back of the film. The lack of penetration must be compensated by increased intensity of the incident light. The result is an image in which the developed silver is concentrated close to the exposed surface and is likewise more nearly limited to the area of direct exposure. There is a further advantage in that lenses of greater resolving power are possible with the light of shorter wave length. In "single-film" systems, in which the sound is necessarily recorded on the same film as the picture negative, the use of ultraviolet light has contributed in a major way to improvement in the quality of the recorded sound.

Within recent years new fine-grain films have been made available

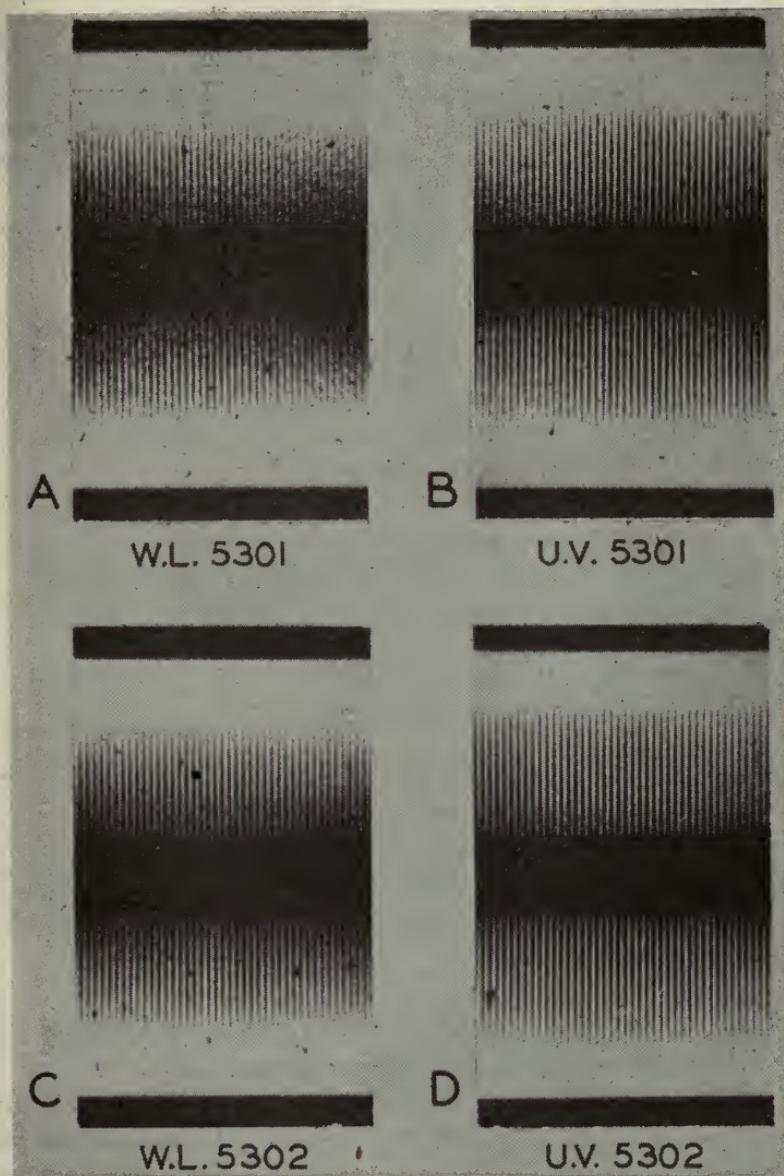


FIG. 18. Enlargements of 7000-cycle 16-mm tracks made by optical reduction. *A*—White light print on EK-5301 (standard 16-mm positive); *B*—Ultraviolet print on EK-5301; *C*—White light print on EK-5302 (fine-grain); *D*—Ultraviolet print on EK-5302.

giving much finer resolution than the previous recording stocks.³¹ The results are reduced distortions and better reproduction of high frequencies. Ultraviolet light may also be employed to advantage when recording or printing on fine-grain films. High-intensity mercury lamps⁷ have contributed in an important way to the solution of the problem of obtaining adequate exposure for printing on slow films, especially if ultraviolet light is wanted.

The treatment of lens surfaces in optical systems to reduce reflec-

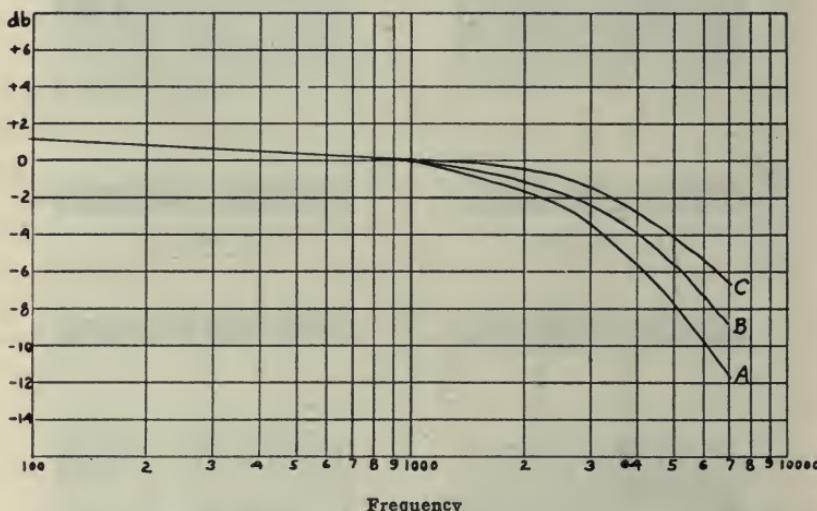


FIG. 19. Improvement in high-frequency response obtained by the use of ultraviolet light and fine-grain film. Ordinates are measured outputs of 16-mm optical reduction prints, all made from the same 35-mm negative. A—White light on EK-5301 (standard recording film); B—Ultraviolet on EK-5301; C—Ultraviolet on EK-5302 (fine-grain).

tions has also contributed to improved resolution, by reducing stray light and increasing the amount of available useful light.³²

Fig. 18 shows enlargements of several recordings of high-frequency waves, illustrating the improved sharpness and cleanliness of the outlines of the waves, resulting from use of UV light and fine-grain films.^{29e} Fig. 19 shows the improvement in high-frequency output.

Differences between Density and Area Recordings.⁵—Since the sound track print is on the same film as the picture, it must receive the same development as the picture, and picture development has been practically standardized at a gamma of about 2. Hence the

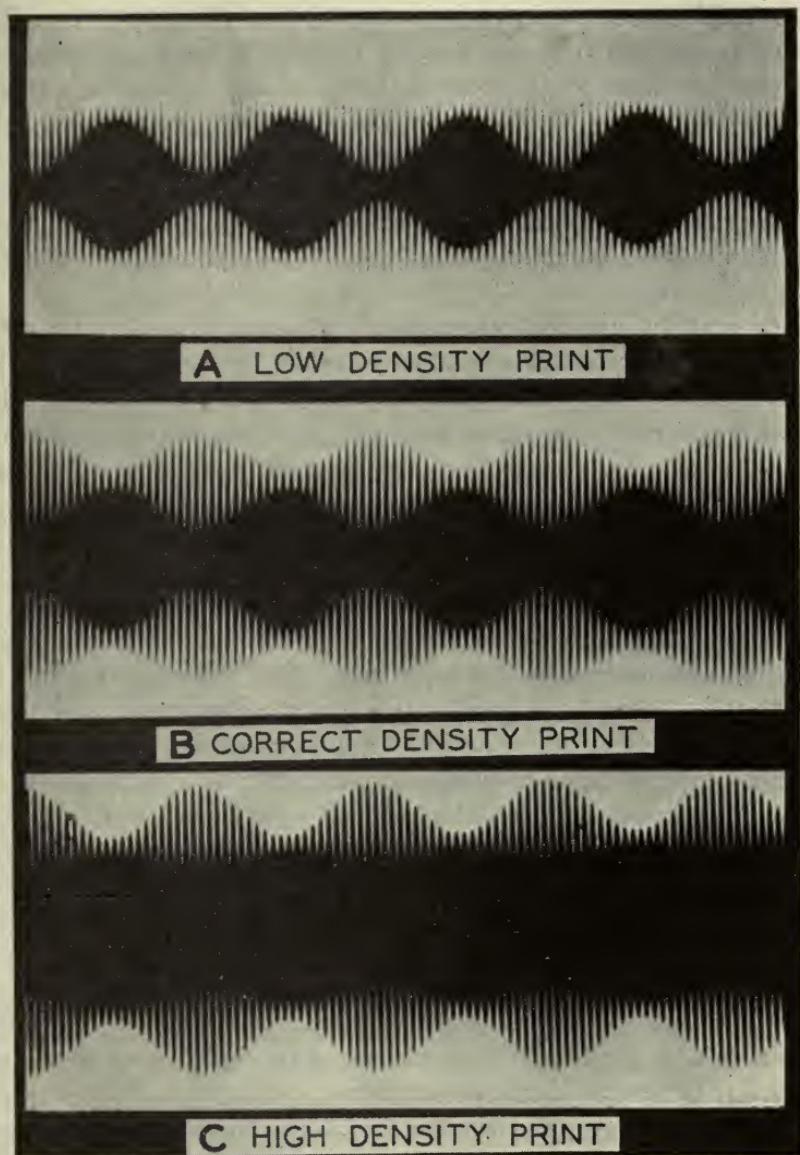


FIG. 20. Cross-modulation tests, showing rectification effect when the print density is too low (A), or too high (C).

desired difference in contrast (or gamma product) for the 2 systems must be provided by the difference in negative development.^{9,24,25} In general both systems use the same types of film for the original recordings or negatives, the density recordings being developed in low contrast, negative-type developers to gammas ranging for the most part from 0.4 to 0.7, while area recordings are developed to gammas of 2, 3, or even more, in many cases stopping just short of the production of developer fog.³³

Film-grain noise is more of a problem in density recording, and for that reason the timing of ground-noise reduction systems is made faster.^{5,17}

Both systems are subject to losses in high-frequency response, resulting from finite slit size, and imperfect resolution in the film image.³⁴ The area system imposes more severe requirements with respect to narrow recording beams,^{4c} and freedom from printer slippage,³⁵ but owing to the higher development, the required densities are obtained with less exposure, making it practical to record with narrower slits.

The principal cause of distortion in the density system is lack of linear relationship between print transmission and negative exposure.^{24,36} This affects all frequencies in the audio spectrum, the distortion increasing with the amplitude. The objective of much of the sensitometric studies applied to density recording is to provide as large a range of substantially linear characteristic as possible. At best a density track cannot modulate quite as much light as an area track without serious distortion. To partly offset this disadvantage, the variable-density system overloads more gradually than the variable-area.^{37a} This results in a less objectionable effect from overload, and overloading is permitted more freely than in the area system.

Distortion in the area system is caused principally by spreading of the image beyond the theoretical boundary, owing to the finite width of the recording slit,^{34a} and to scattering of the light within the emulsion.³⁰ (It is possible with low exposures, and high contrast, for the black area to be less than the exposed area, but with the high exposures employed in area recording, the black area always steals something from the clear.) The distortion resulting from image spread is most serious with high frequencies, and is practically negligible at low frequencies. By proper printing exposure, the image spread in the print can be made to largely cancel the effect of that

in the negative,^{30,38} and control of this factor largely dictates the printing and development of variable-area tracks.

Where operations are carefully controlled, the selection of the proper printing exposure for an area recording is based on a routine "cross-modulation" test. A 9000-cycle wave is modulated from zero to about 80 per cent amplitude at a rate of 400 times per sec. The negative if reproduced may show considerable 400-cycle output (although there was none in the input), but a print of optimum density will show practically no 400-cycle output.³⁸ Fig. 20 shows enlargements from a cross-modulation test. At *A* the image spread in the print does not compensate for that in the negative. At *B* the printing is correct and practically no 400-cycle output is produced. At *C* the print is too dark for the amount of image spread in the negative and again 400 cycles appear in the output.

Distortion in either system can be measured by recording sine waves, and measuring the harmonics^{36a,c} in the output with a "wave analyzer." A test which is widely used in studying variable-density recordings has been called the "intermodulation" test.^{38b} A low amplitude wave of medium or high frequency (for example, 1000 cycles) is recorded superimposed on a high amplitude wave of low frequency (say, 60 cycles). The fluctuations in amplitude of the output of the higher frequency wave are measured and constitute an index of the variations in slope of the print transmission versus negative exposure (linear scale) characteristic. Quite large fluctuations (in percentage) of the higher frequency output may correspond to relatively small values of harmonic distortion, thus making the intermodulation test a sensitive one.

Development.³⁹—The problems of the processing laboratories^{21,39c} constitute a whole field of engineering science, quite beyond the scope of this paper, but they are the subject of a large number of the papers appearing in the JOURNALS of the Society, as well as in numerous books on photography. Only one or two items will be mentioned here.

From the recordist's point of view it is important that he be able to judge whether his recordings are being properly processed. He will normally judge this from his sensitometry tests, although these will not in general give any indication of printer imperfections, which may result in wrong track location or excessive loss of high frequencies.

Commercial processing of motion picture film is, for the most part,

done in continuous developing machines in which the film passes successively through developer, rinse, fixing bath, wash, and drying compartments.^{12d,g} Abundant agitation of the developer must be provided¹⁸ to avoid distortions such as underdevelopment of light areas adjacent to dark areas (Mackie line), often noticed in pictures, "directional effect,"^{21e} and influence of sprocket holes on development of adjacent areas.^{18c,d} Machine development makes it possible to obtain better uniformity than is possible in general with development by the rack and tank method, but eternal vigilance on the part of the operators is necessary in order that the developer may be maintained within appropriate limits of activity, and that bath temperatures and drying conditions be held within proper limits.^{21d,25b}

Mention has already been made of the importance of cleanliness of solutions and air.

Developer formulas are said to be as numerous as the commercial laboratories where they are used, but they fall in general into 2 classes.

Negative-type developers are used for picture negatives, and for variable-density sound negatives, and are distinguished from positive developers by giving lower contrast, requiring more development time and, in general, by the use of borax to provide the required alkalinity.^{39b} Negative developers are rated as giving finer grain than positive developers. The difference is decided in the case of picture negative films, but much less pronounced in the case of inherently finer grain films such as cinepositive, sound recording emulsions, and the extra fine-grain films.

Positive-type developers are used for release prints and for variable-area sound negatives. The alkalinity is provided by sodium carbonate. Positive developers act more rapidly and give higher contrast or gamma.³⁹

Rerecording⁴⁰ and Duplicating.⁴¹—In the major picture productions most of the original sound recordings are rerecorded after editing. This permits mixing in sound effects, adjustment of levels, and altering, if necessary, the tonal balance by means of electrical compensating circuits as, for example, reducing the low-frequency components of abnormally heavy voices.

The only way to obtain new picture negatives is by printing to a positive and back to a negative. The same process is sometimes applied to sound records as, for example, to make films for printing elsewhere as in case of export. Special duplicating film emulsions

are employed,^{26,41a} and the processing for best results has been the subject of much study.^{15d,41b} Good results can be obtained from good originals, provided the printer does its part well.

High-Frequency Losses.—Mention has already been made of the principal causes of loss of high-frequency response. Much of the progress toward better sound quality has been in the removal of some of the limiting factors that so restricted the frequency range in the earlier sound records, making them muffled and hard to understand. Better optical systems,^{4,9d} narrower recording slits,^{4c} finer grain films,³¹ ultraviolet light recording and printing,²⁹ lens surface treatment to reduce reflection,³² and better knowledge and control of processing^{34,38} have made most of the improvement possible. One does not find as much literature on the subject of processing for improved high-frequency response in density recording as in the case of area recording, for other factors largely dictate exposures and developments for both negatives and prints. Some indication of expected high-frequency recording and printing loss, under commercial conditions, is given in Fig. 8, curve No. 8 of "Sound Picture Recording and Reproducing Characteristics" by Loya and Morgan^{34d} in the July 1939 issue of the JOURNAL of the Society. In area systems, satisfying the cross-modulation tests,³⁸ while not guaranteeing good high-frequency response, never conflicts.

Compensation of High-Frequency Losses.—The practice was adopted early of compensating for the expected high-frequency loss by exaggerating the amplitudes of the high-frequency components of speech and music at the time of recording. Fortunately for much of our sound recording the components of very high frequency—say, 5000 cycles and above—are not encountered in amplitudes as great as those of the lower frequency components.⁴² Hence it has been found possible to "tip up" the recording characteristic without seriously increasing the tendency to overload. Such exaggeration of the high frequencies in recording is obviously a poor substitute for improving the technique of making the records, or in other words, eliminating the causes of the high-frequency loss. Moreover, the same factors which produce the high-frequency loss produce other types of distortion^{34a,38} which are rendered worse in proportion to the magnitude of the high-frequency recording.

Such progress has been made in improving the quality of recording that it is not now necessary to make excessively large allowance for expected high-frequency loss. However, the practice of some tip-up

has persisted for the following reasons: the simple expedient of widening the reproducing slit causes a relative loss of reproduced high frequency without necessarily introducing any other distortion.⁴³ It has been found desirable, especially with variable-density systems, to permit some of this high-frequency loss in reproduction and compensate for it in the recording, for the net result is a reduction of the loudness of the high-frequency components of ground noise.⁴⁴ It is important that the characteristics of reproducing systems with respect to response at various frequencies shall be brought close to some standard, and the Academy of Motion Picture Arts and Sciences has proposed a standard characteristic for theater reproducing systems.⁴⁴ The proposed standard reproducing characteristic contemplates a tip-up in the recording amounting to about 5 db between 1000 and 5000 cycles.

Printing.³⁵—Most printing is done with sprocket-type contact printers, the negative and the print film being carried on a large diameter sprocket with the negative inside and the illumination coming from within. By choice of sprocket diameter a certain allowance is made for the fact that the negative which has been processed, will have shrunk to slightly smaller dimensions than the fresh print film. This compensation is set for average conditions and when the machines are operating well in other respects, prints made on this type of printer are considered satisfactory. Results with a negative which departs much from average are likely to be poor.^{35e}

The requirement that negative and print of unequal lengths shall pass the identical number of sprocket holes in a unit time, and that there shall be no slippage at any time, involves a contradiction. Only by stretching the shorter of the 2 films can true nonslip action be obtained. A nonslip printer invented by A. V. Bedford solves this problem, not by bodily stretching either film, but by flexing one or both films automatically to the point where the curvature produces the required amount of stretching or compression of the surface of the film which is in contact with the other film. A number of nonslip printers are in commercial use.

Projection sound printing has not found wide application except for making 16-mm prints from 35-mm negatives.^{29e} In some projection printers the negative and print are carried on sprockets on the same shaft.^{45a} This leaves the same possibilities of blurring owing to tooth action as in a sprocket-type contact printer. If independent

filtered drives are provided for negative and print, the blurring which slippage causes in sprocket-type printers will not occur, but the filtering systems must be excellently designed or objectionable speed fluctuation effects may result.^{45,46}

Compression.³⁷—The principle of automatic volume control has been of great help in sound recording. The audio-frequency circuit is divided into 2 channels and the voltage from one of the channels is rectified, and the rectified voltage used to reduce the gain in a variable-gain amplifier stage in the other channel, whose output is to be recorded. This has the effect of reducing the disparity between the stronger and the weaker sounds and improves intelligibility, particularly if the sound is to be reproduced under adverse conditions.⁴⁷

Slit Dimensions and Angle.—It has already been indicated that the ideal recording light beam would be infinitely sharp at the film, but this is incompatible with adequate exposure. The obvious harm of too wide a recording light beam is that it will fail to register the waves of very high frequencies. It can also result in serious wave form distortions, especially at the higher frequencies.^{34a} In the RCA recording system the slit image is 0.00025 in. wide at the film.^{4c} Variable-density recording systems have used a somewhat wider image. It is difficult to state in simple terms the width of the image used in light-valve recording, for this varies in accordance with the ground-noise reduction bias. Without any bias the valve is usually set to give an image 0.0005 in. wide.⁹

It is obvious that the recording and reproducing light beams should both be set perpendicular to the direction of motion of the film, for unless their angles are identical, distortion will result.⁴⁸ Methods have been worked out for setting the angle of the recording slits and also the positions of the triangular masks used in variable-area recording systems, with the required accuracy. In reproducing systems the correct adjustment is made with the help of a film which has been recorded for this special purpose.⁴⁹ Analyses of the effect of the finite reproducing slit width indicate that this causes no distortion except the loss of high-frequency response.⁴³

Uniformity of Slit Illumination.—Lack of uniformity of the reproducing beam throughout its length is the cause of some distortion when reproducing variable-area tracks, and much study has been given to the problem of improving the uniformity.^{7a} Analyses have also been made which show that the magnitude of the distortion is

much less than might be inferred from a casual examination of a curve of light distribution.⁵⁰

Constant Speed.^{46,51}—All who have had experience with recorded sound recognize the importance of minimizing speed fluctuations both in recording and in reproducing.^{46a,b} Propelling the film through the recording or reproducing light beam on a sprocket is almost sure to give rise to measurable disturbance at the tooth frequency or 96 cycles per sec.^{46c} However, a number of recorders operating in this manner have given creditable results. Conditions for direct sprocket drive are more favorable in the case of a recorder because it is always working with new film,^{46g} whereas printers^{35e} and reproducers must work with film of various degrees of age and shrinkage.⁵²

A preferable arrangement for both recording and reproduction employs a smooth drum on which the film is carried past the optical system. Flywheels are used to resist changes in speed. The serious problem in this construction is that the flywheel tends to oscillate above and below its correct speed. A number of damping systems have been employed to prevent such oscillations. The reader is referred to some of the numerous papers on this subject⁴⁶ for explanations and descriptions of methods of measuring the speed fluctuations,^{46k,l} and descriptions of damped mechanical filtering systems for providing uniform motion of the film.

Weaving and Track Placement.—In machines of the drum type dependence is placed on flanged rollers for guiding the film to the correct position on the drum. A rubber-tired pressure roller is usually employed to prevent slipping on the drum. The pressure roller not infrequently causes instability in the film position resulting in sidewise "weaving." With proper design this does not need to occur.^{46c}

A standardized "buzz track" test film is employed to check reproducers for track placement and weaving.⁵³ The area normally scanned by a correctly located reproducing beam of standard size is clear, while on either side, tones are recorded. If adjustment is correct these tones are not heard in reproduction. If there is weaving they are heard intermittently. Test films for checking reproducers in other ways have been made available.⁴⁹

Sprocket Hole Modulation.⁵¹—Mention has already been made of speed fluctuations resulting from sprocket tooth action. Aside from the speed effect, the misfortune that the sound track is close to the sprocket holes gives rise to 96-cycle hum owing to the fact

that there is freer circulation of the developer opposite the sprocket holes than between, and consequently the film receives more development and is darker.

Much effort has been devoted to minimizing the 96-cycle hum caused by the proximity of the sprocket holes.^{18c}

Sixteen-Millimeter Recording.⁵⁴—Only painstaking developments have made it possible to satisfactorily record the high frequencies on 35-mm film. Sixteen-millimeter film travels only 40 per cent of the speed of 35-mm film. This means that the waves must be compressed longitudinally and only with utmost refinement can reasonably good high-frequency response be obtained from 16-mm film. Actually we are forced to be satisfied with considerably lower standards than we expect from 35-mm film. Packing the waves into a shorter length of track increases the tendency to cross-modulation. The methods of control of cross-modulation are (or should be) essentially the same as in the case of 35-mm tracks, except that the modulated high-frequency wave has usually been taken as 4000 or 6000 cycles instead of 9000 cycles.³⁸

The problem of constant speed is also rendered much more difficult by the low average speed of the 16-mm film.

In the most successful large-scale production of 16-mm prints, it is common to employ some compression when making the negative, to improve intelligibility, and low-pass filters are employed to eliminate some of the higher frequency components which could scarcely be successfully recorded if present.

Contact printing is at present the general method, but excellent results have been obtained with optical reduction printing.^{29e,45} (See Figs. 18 and 19.)

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THE PHOTO-TEMPLATE PROCESS*

FAUREST DAVIS** AND CYRIL F. HARRIS †

Summary.—Any post-war planning concerning engineering and tooling is certain to include the photo-template process. This process is one of the many engineering short cuts developed as a result of the pressure of war production. It is concerned with the accurate, rapid, and economical reproduction of dimensionally stable engineering drawings, whether on a mass-production or single-piece basis; it completely eliminates the tedious layout step in the shop with its attendant cost in man-hours and liability to error, and cuts costs appreciably in other phases of production operations.

At present it is largely used in aircraft manufacture, but its extreme flexibility and high accuracy, as shown by numerous examples, point to its use elsewhere. The method and materials used at the Lockheed Aircraft Corporation are described. Warnings are given, however, concerning certain hazards and difficulties; means of overcoming them are also given. Applications of this important engineering tool to other than aircraft fields are indicated.

While the photo-template process owes its rapid development to the need for mass production of aircraft, its field is limited neither to aircraft nor to mass production. It has been developed as a very rapid means of transferring engineering data from the drafting room to the shop, and should be of interest to most engineers.

In industries where templates or patterns are made, it is common practice for a designer to furnish rough data to a draftsman, who prepares upon paper or cloth a detailed drawing of a projected construction giving over-all and other necessary dimensions. The shop receives its engineering data on one of these media, and a duplicate is then laboriously made by hand from the dimensions given, or scaled off, which is equally troublesome. Whether a template or a finished article is desired, this layout procedure must be gone through. It not only takes considerable time but requires skill, frequent accurate inspection, and is highly subject to human error. One aircraft com-

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** Ansco, a Division of General Aniline and Film Corp., Binghamton, N. Y.

† Photographic Dept., Lockheed Aircraft Corp., Burbank, Calif.

pany places a cost figure of \$22.75 per sq ft on templates produced by this method, and it is proposed to show how a new method effects a tremendous saving in time and money.

Because of lofting practice in the aircraft industry, original drawings are ordinarily made on sheet metal instead of dimensionally unstable materials such as paper or cloth. In the new method, particularly as applied to the aircraft field, actual dimensions are rarely shown on the original metal drawings, which are usually made full scale. These drawings logically start at the loft floor where the skin contours are developed, and proceed from there to other engineering departments which fill in the contour envelope with the framework required to support it and the machinery needed to operate it. All tridimensional structural parts appertaining to this envelope are shown in the drawing plane in solid lines to show the final position of the part and in flat pattern lines to show the actual shape of this part laid out in the flat.

In general, a large number of individual parts to be fabricated from duraluminum sheet or other material are shown on a single master drawing known as a "Detailed Assembly Template," which to an unaccustomed eye is a hopelessly complicated drawing; actually however, it simplifies the manufacture and accurate assembly of complex structures, and assures easy and rapid interchangeability of all parts in the finished product. This is particularly important in wartime when composite airplanes are made from parts of salvaged planes which have been only partially damaged. Clearly, for the type of drawing described, a high grade of engineer-draftsmanship is required, particularly since each designer has only a relatively small section of an airplane to work upon, and therefore great accuracy is needed at the beginning to ensure close coordination of all parts of the finished product. It can be seen that the making of full-scale original drawings simplifies the work of these men considerably.

From this point on, the description of method is as developed at the Lockheed Aircraft Corporation, where the use of the camera method was indicated for their particular requirements. There are alternate methods, such as reflex and X-ray, which have been developed in other airframe plants to meet their special requirements. An evaluation of the merits of these various methods is not within the scope of this paper.

The original drawing is, of course, kept in engineering files for reference but is sent out for a brief period to be photographed. Actual

drawing is done with a 6H graphite or silver-solder pencil onto a box-coat of lacquer covering primed sheet metal. Lacquers have been especially made for template work with a view to providing a proper tooth for the drawing medium, sufficient hardness so that this medium will not dig in, and with enough plasticity to prevent chipping in drawing. Colors should give as much visual contrast as practicable between the medium and the background without producing eyestrain for the engineer-draftsmen, and at the same time provide a spectral reflectance lying well within the sensitivity range of the copying materials, preferably at the peak. The yellow- and blue-green colors found to satisfy most requirements give low visual and photographic contrast, and in photographing the drawing this contrast must be considerably enhanced by the use of an inherently contrasty lithotype plate and a highly energetic developer.

A common size for an engineering drawing on metal is 4 X 12 ft; it is usually galvanized iron sheet and in this size weighs about 100 lb. The optical method of making reproductions is ordinarily used, and a large copy camera of very rugged construction is required to support the metal sheet for copying. One such camera has a finely machined double rack and pinion, the pinion being geared to an electrical drive so that both lens- and copy-planes can be moved and set to ± 0.0005 in., the maximum allowable to satisfy the demands of the method. This entire camera is hung from a monorail slung in a cradle of vibration-damping coil springs, certainly a desirable feature in cases where heavy stamping and forming machines are operated nearby.

Negatives are made to any convenient reduction, usually 5:1. Copy is crosslighted by any of a number of suitable sources: high-intensity carbon arcs, air-cooled high-intensity quartz mercury tubes, large banks of fluorescent tubes, incandescent lamps, and so forth, care being taken to minimize specular reflections from the discrete graphite or silver particles making up the line image. Full-scale reproductions from these negatives are allowed a tolerance of ± 0.001 in. per ft, and if during negative making the copy is excessively heated, by arcs for example, a reproduction from the negative onto cold metal at the same track settings will result in a rejection for oversize; if during projection a cool light source is not used, expansion of the plate will again result in oversize images—particularly if a large number of parts are being made from the same negative. Thus rigid temperature control throughout all phases of the copying cycle is

indicated. In the absence of such control, offsize images are the rule unless a test strip or other means to check size is used. This is a wasteful procedure adding about 50 per cent in camera crew time to a job. Negatives are on call 24 hr per day throughout the year, and it has been found that without adequate control, temperature differences owing to diurnal as well as seasonal changes give extra-tolerance images which affect the accuracy of the product, and therefore seriously hamper the smooth flow of production. In the long run, capital outlay for temperature-control equipment pays. Incidentally, in case high-intensity carbon arcs are used, a health hazard similar to that presented by projection booths must be taken care of; the reflector for each arc bank should be individually vented to carry off toxic nitrogen dioxide to safeguard the health of the workmen.

Perhaps the most interesting feature of the entire process is the method used in sensitizing various materials for reproduction. Simply stated, the method consists of spraying a gelatino-silver halide emulsion onto the materials to be sensitized. For most purposes a color-blind process-type chlorobromide emulsion is satisfactory, and can be either made up or obtained from at least 2 manufacturers of photographic materials.

The emulsion as supplied arrives in cooled, well-insulated cases, in the form of lumps or noodles, and is stored at 45 F. For use it is usually extended with distilled water in varying amounts up to 1:1 depending on the richness of the emulsion and the working conditions. The emulsion and extender should be gently warmed in a steam-heated water jacket to 95 F, during which time any finals are added. Ordinarily about 20 cc per liter of 10 per cent chrome alum hardener is all that is required in the way of finals, but occasionally substances are introduced to minimize foaming or to give better wetting action.

The spraying equipment is standard as used in paint-spraying operations with the exception that any metal parts which come into contact with the emulsion should be of stainless steel. In cases where the emulsion is fed through a rubber hose from a pressure pot to the spray gun, the hose should be of the sulfur-free type. The pressure pot is itself a water jacket to maintain the emulsion at proper working temperature and is kept under just sufficient air pressure, about 8 lb, to feed the emulsion through the flexible line to the gun, where a second compressed-air line blows the emulsion into a fine spray. The pressure on the second line can be adjusted at the spray-head and will depend on the volume of emulsion delivered to the head, the type

of spray desired, and the speed of coating. A low-intensity filtered light can be attached to the spray-head to inspect the coating operation as it proceeds. Large metal sheets are usually coated at an angle of 75 degrees, small pieces in a horizontal position.

An adequate spray booth with input and exhaust should be provided, not only to meet ordinary industrial hygiene requirements but to safeguard workmen against a hazard present wherever free silver or its compounds are present and can be taken into the body. This hazard can result in an ailment known as argyria, the only effects of which according to data gathered in the medical field are cosmetic; the extent to which it is disfiguring is dependent on the amount of silver the body has accumulated after a certain critical level has been exceeded—about 0.91 gm of metallic silver, and shows up as a darkening of the skin, especially on exposure to light. A careful check of the spray-room atmosphere revealed an average silver concentration of 0.01 milligram per cubic meter during spraying. In the absence of official safe limits for this new method a cumulative level of 0.18 gm, about one-fifth of the minimum found to result in pigmentation, was arbitrarily established. Average inhalation is about one cubic meter per hr, and since the actual spraying operation takes only one hr per day, it would take a workman 60 years to arrive at the arbitrary safe level, or 300 years to accumulate a known disfiguring amount of silver. This arbitrary level assumes that the entire amount of available silver halide is inhaled and deposited in body tissues.

The input to the spray booth supplies 15,000 cu ft per min, and the exhaust removes 12,000 cu ft per min, so that a plenum is provided during spraying to ensure silver-laden particles passing into the exhaust. Although it is thought that the face velocities thus provided are adequate to remove the hazard, workmen are required to wear positive pressure masks pending results of further studies along these lines. The input on this spray booth draws on the outside atmosphere for air, which passes only through dust filters, this particular setup having the good fortune to be located in a fairly clean atmosphere in an isolated spot. In heavily industrialized sections where sulfur and other substances known to cause photographic fog are present in the atmosphere, a filtering system to remove them would have to be provided. However, even under fairly clean working conditions great care must be taken to minimize the dangers of fog and all steps of the coating procedure must be carefully watched.

The emulsion is not chilled to set it up as in the case of commercial production of sensitive materials, where a perfectly uniform coat of considerable thickness is required. The fresh sprayed stock is placed in a drying cabinet containing moisture-absorbing pads, thermostatically controlled heating coils, and a blower to keep 95 F air circulating. Sensitized stock is ready for use or storage in 20 to 25 min.

The same top lacquer that is furnished engineering loft for original drawings is used without substratum of any kind in the gelatin-emulsion-spraying operation, bond being effected mechanically by the same material that provides tooth for the drawing medium. This lacquer, in addition to the several requirements specified for original drawings, should be photographically inert, dry to handle in less than 5 min, and stay put if the relative humidity drops to 15 per cent and the temperature of the metal gets to 125 F, when the gelatin exerts a tremendous pull on its anchorage. These conditions, which occur during transfer and in exposed storage areas in semidesert regions, are the most severe yet encountered.

It was stated previously that original engineering drawings were filed for reference, and under the old method when minor modifications were made to effect design changes—even when alterations or additions affected only a small part of an assembly—it was necessary to make an entire new original. However, with the technique described the old original is still retained as a record of manufacture up to the date of the change, but instead of making a complete new drawing by hand, a new photographic "drawing" is made in the Photo Department omitting the parts to be changed by either opaque the negative or by removing the obsolete lines from the positive with a damp eraser. Thus a notable economy is effected, and the engineer now merely draws in the new parts and the same process is followed as with the first drawing.

The great bulk of the work, however, is for tool material, which requires a special lacquer with greater plasticity under the top lacquer to withstand the shocks of punching, shearing, and other tooling operations necessary to template making. This lacquer can be of the nitrocellulose type, but can equally be of other types as long as requirements concerning plasticity, adhesion, and photographic inertness are met. Emulsion is not sprayed direct to this particular plasticizer lacquer for 2 reasons: a substratum is required to provide a bond with the emulsion, thus interfering with production and increas-

ing costs; and more important, because of its plasticity this lacquer will not hold the shrinking gelatin in place during exceedingly dry summer conditions, and allows it to break when the resulting tension gets too great. Thus the fine-line image can be distorted unless the less plastic top lacquer is used to provide firm anchorage for the gelatin.

The foregoing description of the photo-template process has dealt only with sheet metal templates used for patterns, inspection guides, jigs, *etc.*, or aluminum to be fabricated and used as actual parts for prototype airplanes. However, many other materials are used such as heavy plate often weighing several hundred pounds for drill jigs, Masonite for form blocks, various plastics for dials, charts, scales, and the like, and plywood, which is well suited to electrical layouts marking the position of each component and all connecting wires, for duplication of cable-form layout panels, or for mockup work. These indicate just a few of the uses of this new tool in one plant, which by using the procedure outlined, brought its costs for completed templates from \$22.75 per sq ft to \$3.05—effecting a saving of over \$7,000,000 in 3 years!

All of the cameras now in use for this type of work were adapted from the photoengraving field and have certain shortcomings. They are all inadequate from the standpoint of supporting heavy loads frequently put on the copyboard—usually heavy plate for drill jigs and the like. This particular inadequacy results from the fact that present cameras have movable copyboards, but when time and materials permit, a camera will be built especially for the process in which the copyboard will be rigidly fixed and capable of supporting a ton of material if necessary without putting undue stress on the mechanism or altering the relationship between the copy-, negative-, and lens-planes. In addition to this, some cameras are not satisfactory because they have inadequate means for accurate positioning of two of the working planes. New design fundamentals are being laid down for the construction of cameras to meet special photo-template requirements.

The photo-template field is wide open for development and application, and the near future will provide many interesting variations on the fundamental method as outlined here. Its extreme flexibility and accuracy have resulted in a rapidly growing demand for its use in aircraft production alone, and the post-war life of this youngster cer-

tainly looks promising in fields such as electrical and automotive engineering, die-stamping, and shipbuilding, to name but a few.

Under peacetime conditions the time- and money-saving features of the photo-template procedure certainly make it desirable; but under wartime conditions the value of the time-saving factor alone cannot be reckoned in terms of money.

A NEW 35-MM PROJECTOR WITH A NEW LIGHT SOURCE*

THEODORE SCHAFFERS**

Summary.—The following paper discusses the use of a water-cooled high-pressure mercury lamp in a motion picture projector of new design. The factors involved in the construction of an illumination objective for the lamp, light flux and color, cooling system, and safety factors are described.

Since the early days of the film projector, pioneers in this field have tried in many ways to increase the intensity of the light source. The carbon arc was a definite improvement over the existing light sources of its time, and it has been perfected considerably during the last decades. Most successful was the so-called high-intensity carbon arc which today is standard equipment in every modern motion picture theater.

Electric filament lamps have never been able to compete with carbon arcs in intensity. It is understandable, therefore, that another light source, which would not only match but in some cases surpass the intensity of the carbon arc, has long been sought. After years of research, such a light source has been developed by the Philips Research Laboratories. It is the water-cooled high-pressure mercury lamp. This lamp has the great intensity so necessary for film projection, and has none of the disadvantages of the carbon arc. In addition, it has the added advantage of less heat development.

Because of the small dimension of the mercury lamp, it has been possible to simplify the new projector to a great degree. Its appearance, therefore, differs from that of existing projectors since it is possible, where the mercury lamp is used, to build 2 projectors, one above the other. This construction makes the projector particularly useful for television, since the distance between lens housings is very short. Of course, certain modifications must be made in the projector mechanism before it is adaptable to television projection.

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** North American Philips Company, Inc., New York.

For the projection of noninflammable film, this projector has the advantage of producing less heat and so the film is not heavily loaded



FIG. 1. High-pressure mercury lamp mounted in semicylindrical housing.

thermically. About 90 per cent of the heat rays are absorbed by the cooling water and never reach the picture gate.

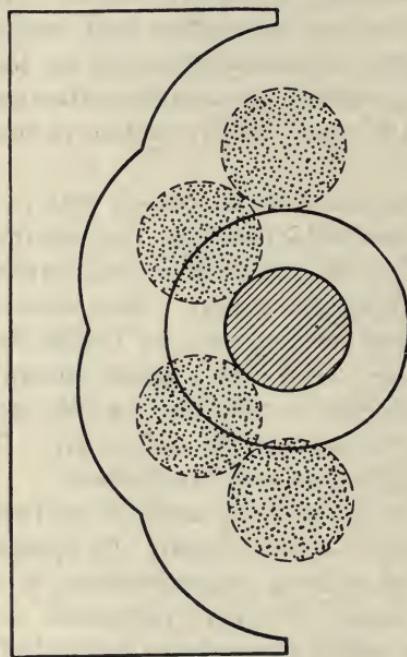


FIG. 2. Drawing of cross section of mirror and lamp showing 4-image reflection.

working voltage is 500—current is 2 amp.

Optical System.—The quartz tube is mounted in a semicylindrical housing, shown in Fig. 1. In projectors, it is desirable to con-

Light Source.—Structure of the water-cooled high-pressure mercury lamp, its quality of radiation, brightness, and source-size limitations have already been dealt with in this JOURNAL.¹

The tube is of quartz and is water-cooled. Two tungsten wires, led in through the ends of the tube, serve as electrodes. In addition to a small amount of mercury, the tube contains some argon gas to facilitate ignition. The mercury vapor pressure is over 100 atmospheres and the light flux is 60,000 lumens. The d-c voltage is obtained by means of a special rectifier—ignition voltage is 800 and

centrate as much light as possible in the neighborhood of the light source. However, a certain lateral deviation is necessary since the strong refraction of quartz makes it impossible to send light through the free space between the constricted discharge and the inner wall of the mercury tube.

Light emitted backward by the lamp is directed forward by a special mirror, shown in Fig. 2. If the ray paths are examined in a transverse cross section, 4 images can be seen in addition to the discharge. Together, they form a lighted surface about 0.316 in. in



FIG. 3. Twin lampholder showing condenser lens.

width. In the longitudinal section, there is no focusing—this is unnecessary because of the oblong form of the light source giving the rays sufficient angle of divergence.

Fig. 3 shows the special lampholder in which 2 mercury lamps are mounted. Figs. 4 and 5 show the cross section of the design. The semicylindrical housing is closed by a flat piece of glass. A plano-convex lens receives light from the mercury lamp at a divergence angle of about 90 degrees. Refraction of this lens is relatively small because one surface is bounded by water instead of air—therefore, a second condenser lens must be used. The shutter rotates in the space between the lenses. Reflector design is very important since it makes

possible the use of direct and reflected light from the mercury lamp to provide uniform illumination of the film.

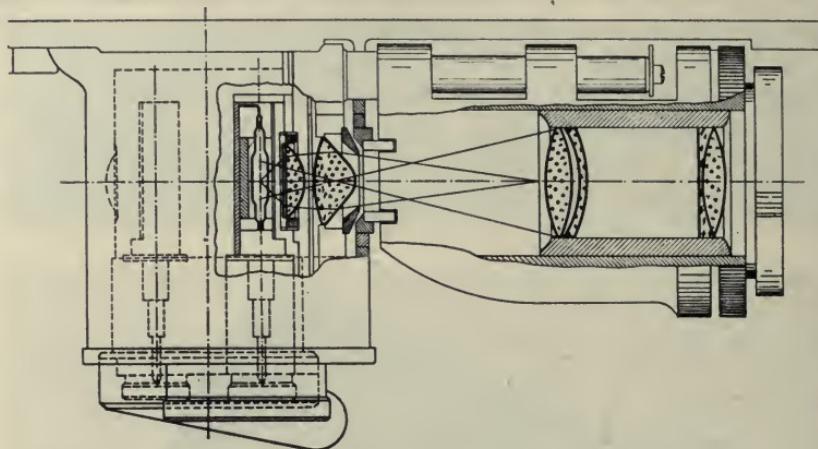


FIG. 4. Cross section of optical system. top view.

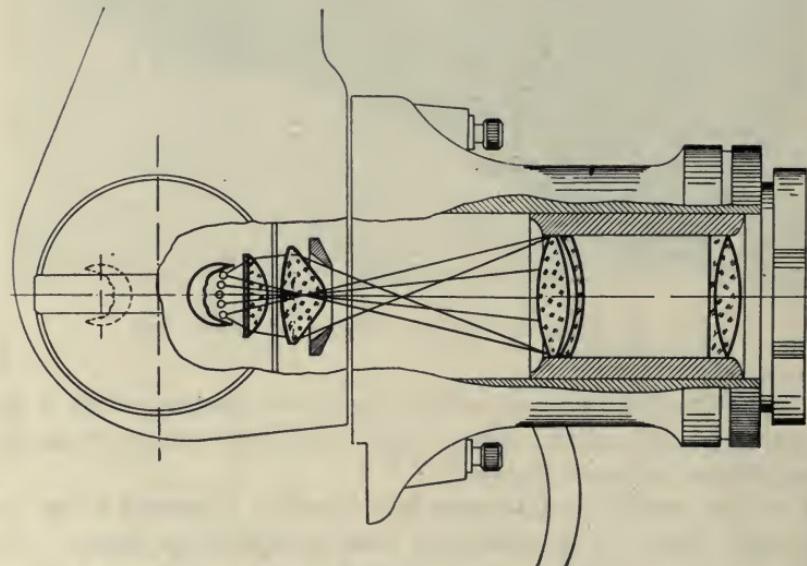


FIG. 5. Cross section of optical system, side view.

Light Flux and Color.—Light flux directed on the screen from the high-pressure mercury lamp is very similar to that of the 45-amp high-intensity carbon arc. With the shutter rotating without film, the mercury lamp intensity is about 2500 lumens and is blue-white

in color. At low mercury vapor pressures the spectrum is not continuous but consists of a number of lines, namely, a green one, a yellow one, and several blue. However, when the mercury vapor lamp is subject to high pressure, there appears a continuous background between these lines. The more the vapor pressure is increased, the more the spectrum approaches that of an incandescent body. This spectral composition is of particular importance when color films are shown. In that case, the light must be white and must have about the same relative distribution of wave lengths as daylight. By increasing the specific loading of the mercury lamp, very satisfactory color reproduction is possible.

Cooling System.—Circulating water is used to cool the lamps and is supplied through a hollow-tapered shaft on which the lampholder is mounted—only the lamp in operation is cooled. Connections can be made to the normal water supply if pressure is sufficient to deliver 2 gal per min during change-over. Delivery of only one gal per min is required for operation of one lamp. A pressure tank, connected to the water supply line, takes care of slight fluctuations in water pressure—in this way, the water flow is made practically constant.

Construction of Complete Projector.—Twin projector construction is made possible by use of the mercury lamp. Fig. 6 shows the operating side of the projector. Film magazines are mounted in the space ordinarily occupied by the carbon arc and the monitor speaker is mounted on the base.

Control panel, from left to right, carries 2 switches for controlling treble and bass notes, and 2 plug-in switches for regulating volume from projection booth or auditorium. Below the volume-control

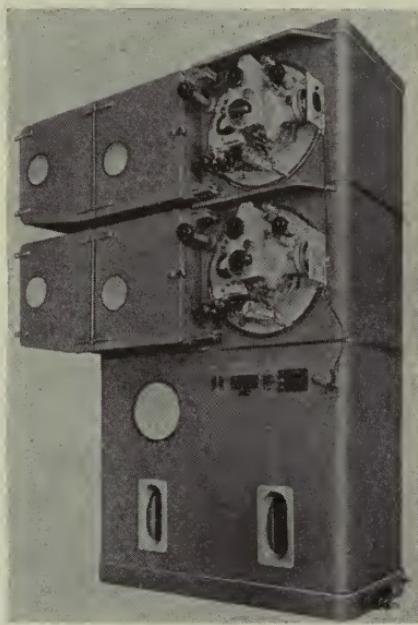


FIG. 6. Operating side of complete projector.

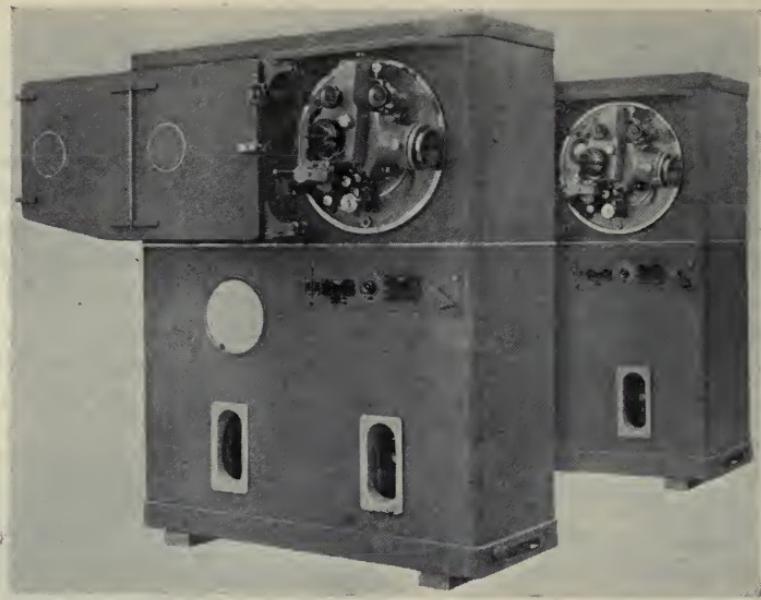


FIG. 7. Single execution of the projector.

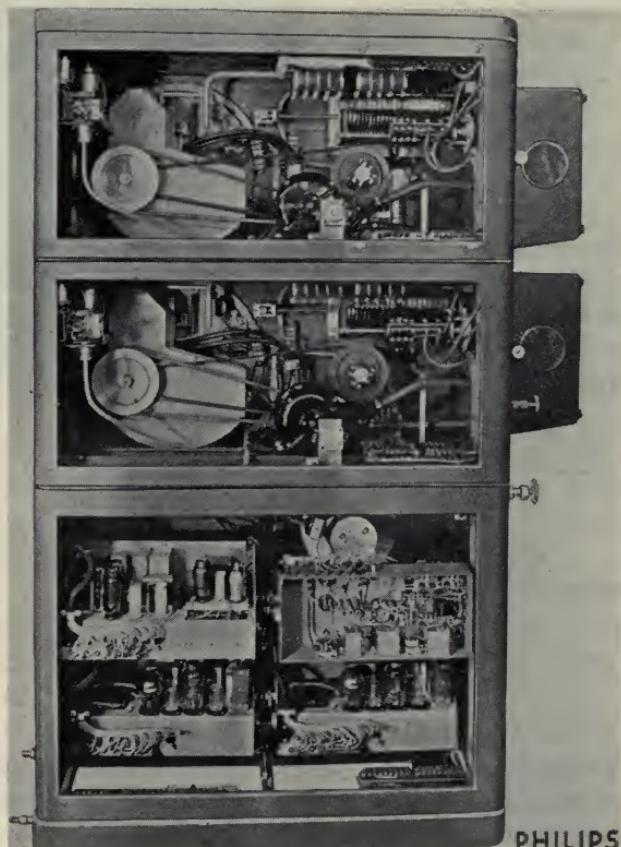


FIG. 8. Inside of projector showing operating parts.

arrangement is a switch that connects monitor speaker to either amplifier. To the right are the volume control and 3 plug-in switches for film, phonograph, and microphone reproduction. There is also a lever switch, connected by a flexible cable to 2 shutters, for instantaneous sound and picture change-over.

A single execution of the mercury lamp projector is shown in Fig. 7.

Fig. 8 shows an inside view of the operating side of the projector. The 2 upper compartments are identical in layout. They contain, from left to right, a pre-amplifier, a projector housing, a driving motor, a take-up clutch, and a controller drum which provides necessary connections for projector motor, mercury lamp, and safety switches. In the base are the amplifiers and power supply systems mounted on pivot points so they can be turned to facilitate servicing.

Fig. 9 shows the 2 projector mechanisms—each unit can be rotated to provide an inclination angle of 20 degrees downward and 10 degrees upward. Projector mechanism is mounted on a cast iron disk. The sound-head is incorporated in the projector and the rotary sound drum shaft is coupled to a dynamically balanced flywheel. This is accomplished through a special friction coupling which holds film tension below a specified maximum value. When the projector is started, a pressure roll permits the film to slip with respect to the rotary sound drum. Framing device, control lamps, film rupture switch, and ammeter are also mounted on the operating side of the projector. On the top sprocket is a knob which allows the projector to be turned for checking film threading.

Fig. 10 shows the controller drum and simplified diagram that operates the motor and mercury lamp. The drum has 4 positions which initiate the following actions:

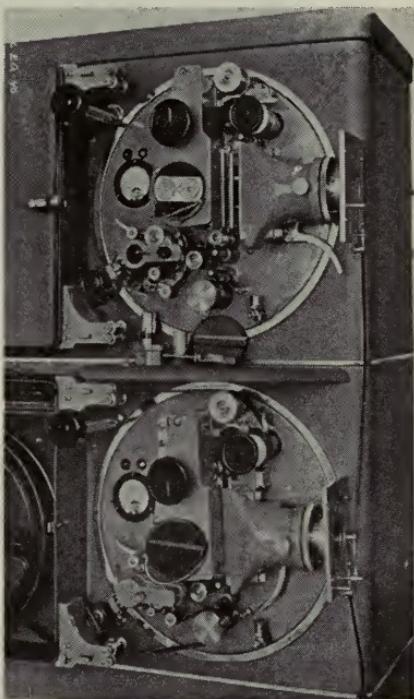


FIG. 9. Detail of projector mechanism.

SIMPLIFIED DIAGRAM OF THE FP2 PROJECTOR
WITH WATER COOLED HIGH PRESSURE MERCURY LAMP

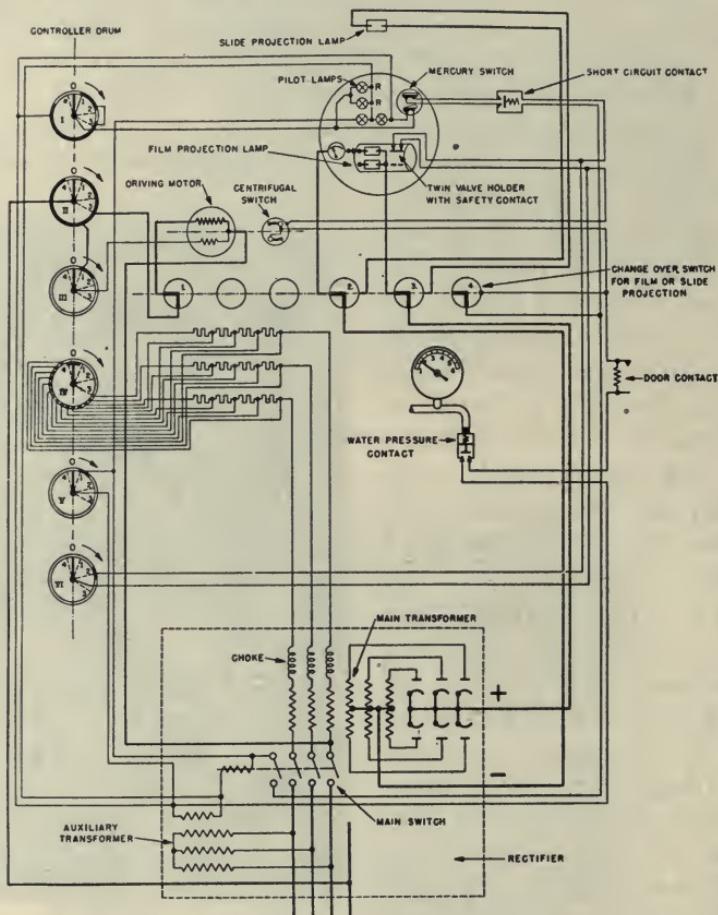


FIG. 10. Simplified schematic of rectifier mercury lamp motor connections.

- (1) Motor is switched on—it has an auxiliary winding to insure smooth starting. In this position, main and auxiliary windings are connected in parallel.
- (2) Auxiliary winding is switched off—motor runs at normal speed.
- (3) Mercury lamp is ignited at 800 v.
- (4) Mercury lamp is switched to working voltage of 500 v.

Many safety features are incorporated in the new projector. If the twin lampholder is turned while projector is operating, the complete installation is automatically shut off. If a mercury lamp breaks

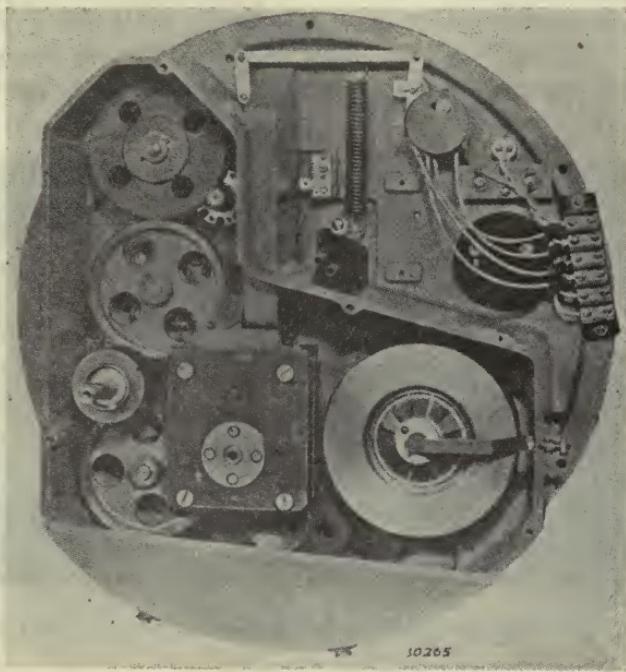


FIG. 11. Gear mechanism, intermittent housing and flywheel of rotary sound drum.

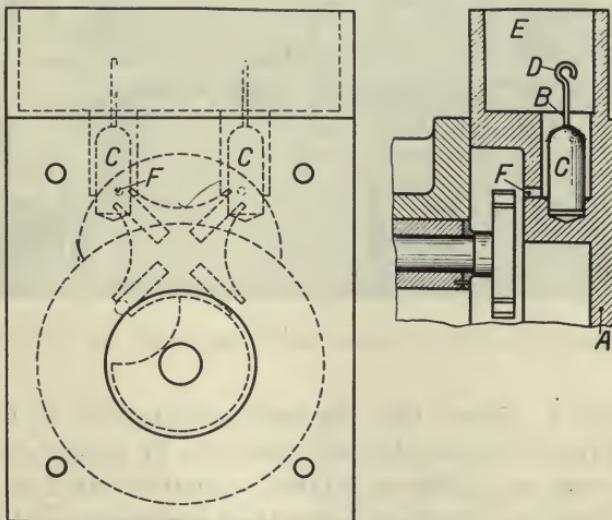


FIG. 12. Diagram showing location of magnetic oil filters.

down during operation, the operator turns the controller drum back to position 2 and revolves the twin lampholder 180 degrees. The spare lamp goes into operation after he turns the drum back to posi-

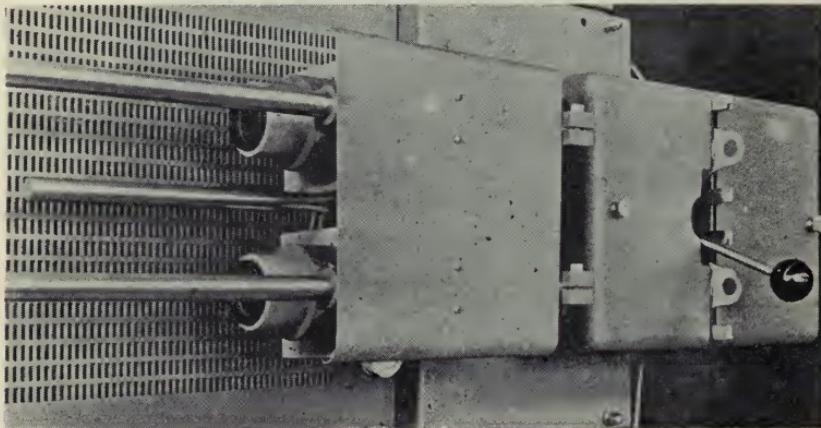


FIG. 13. Lantern slide projector which also utilizes mercury lamps.

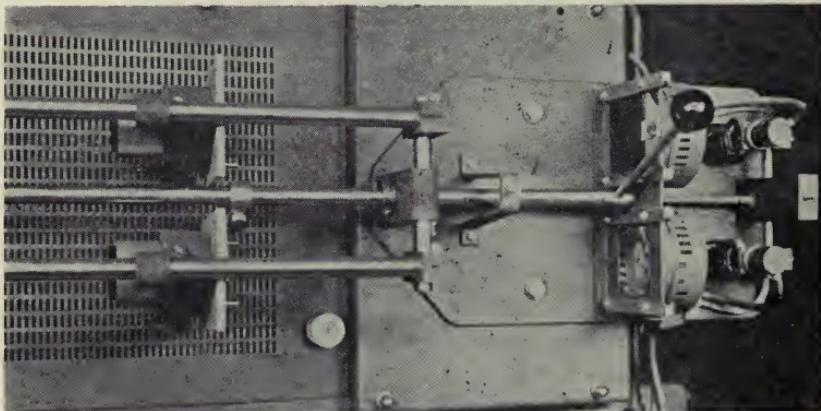


FIG. 14. Cover removed to expose condenser system and lamps to view.

tions 3 and 4. When this happens, the picture is interrupted for a few seconds but sound is not affected. To replace the mercury lamp, the twin lampholder is rotated a quarter turn. In this position, water flow and electrical connections are automatically shut off.

Fig. 11 shows the inside of the gear mechanism. Number of gears

has been kept to a minimum and silent operation has been obtained through use of special materials and a very efficient lubricating system. No pump or oil supply lines are needed since the oil is carried along by the gears themselves.

A magnetic oil filter system is an exclusive feature of the projector design. It consists of a pair of strong permanent magnets, shown in Fig. 12, placed on top of the intermittent mechanism. Steel particles in the oil passing these magnets are attracted and trapped at this point. The magnets can be removed easily for cleaning and thus the life of the mechanism is greatly extended.

Normally, the projector is provided with a lantern slide arrangement, as shown in Figs. 13 and 14. Here again, mercury lamps are used, but the optical system is different than the one used for film projection—this distinction can be seen in Fig. 14.

While this mercury lamp projector has not been very well known in the U.S.A. up to the present, it received wide acceptance in many European countries prior to the war.

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PROBLEMS IN 16-MM CLASSROOM FILM DISTRIBUTION*

OSCAR E. SAMS, JR.**

Summary.—*Some of the problems in distribution of classroom films are discussed, such as subsidies to school film libraries for efficient operation, educating teachers how to use films effectively, and damage to films from faulty inspection and projection. The selection and acquisition of film material to be distributed is a major problem of educational film librarians. The paper also discusses subjects treated in educational films and their part in promoting better international relations.*

It must be admitted at the outset that the classroom motion picture, produced primarily for use in schools, receives almost all of its distribution from the so-called school film library. Of course, a few commercial distributors do make classroom films available to their exhibitors, but this is not the general practice. This discussion, then, shall confine itself to problems usually met by school film libraries in distributing classroom films.

There are 2 major types of school film libraries: (1) that which is usually organized as a part of a college, university, or state department of education and which distributes films over a relatively large territory, and (2) that which is established as a part of a local school system or public library and which distributes films locally only to units of its own system.

A study of the field will show that the film library acting as a department of an organized educational system has a variety of different types of organization. Many of these libraries are subsidized, either in whole or in part, by the college, university or school system under which they operate. This does not mean that the subsidy allows them to operate without financial worries. In public school film li-

* Presented Apr. 19, 1944, at the Technical Conference in New York.

** Director of Domestic Distribution, Motion Picture Division, Office of the Coordinator of Inter-American Affairs, New York.

braries, for instance, the subsidies are usually the only sources of income, and if the subsidy is small, the resulting activity of the distributing department will be small in proportion.

A study of the school systems offering educational film distribution service is most enlightening. Some of the most complete and effective distribution is being done in a few of the relatively smaller cities and counties. On the other hand, it is a lamentable fact that in some of our so-called most progressive school systems in the nation we find little or no film distribution facilities. In these cases much depends on just how much the boards of education have been "sold" on the power of the film in teaching. It can be expected that one of the most fertile fields for projector and film sales after the war will lie in the various city and county school systems.

The college and university film distribution organizations are also organized in a variety of different ways. Most of them are only partially subsidized and, of necessity, must make service charges on all films booked. These charges vary according to the amount of subsidization and the original cost of film prints. Attempts have been made by these organizations in conferences and conventions to standardize booking charges, but such has been impossible up to this time because of the wide variety of organization plans. One library may be subsidized to the extent that it can book a \$45 film for \$1; another will have to charge as much as \$2 for the same film before it can render its service. This lack of standardization in booking charges is one of the main problems in the field.

The effective distribution by some of the agencies is rather amazing when we consider the small amount of money used in the operation. There is one such organization which operates wholly on a subsidy of less than \$6000 a year. Out of this must come the salary of the director and his 2 assistants, to say nothing of the funds that are necessary for film purchases and operational equipment. And yet, this particular library is doing well and is recognized nationally as a major distribution agency. Another well-known university film library must pay completely for its operation from booking fees received.

On the other hand, in some of the more progressive states the film libraries have comparatively few financial problems. Subsidies, together with rental fees, are large enough to permit them to operate efficiently and render the service that should be expected. Two or three state departments of education are subsidized completely and are

doing outstanding work in the distribution of classroom films free of charge in their respective states. Notable in this group is the Ohio Slide and Film Exchange in Columbus.

One of the important extra duties of the educational, noncommercial film distributor is that of the promotion in his area of correct and effective film use in the teaching situation. We hear much these days of the educational film librarian who publishes his catalogue once a year and then sits back to wait for the bookings to come in. This is not true in the majority of cases. Most of the visual education men and women in the field recognize that they have a much larger duty to perform than that of merely making films available. Most of them know that part of their work must, of necessity, be that of educating teachers how to use the film effectively and successfully in the classroom. As a result, many conferences, conventions, and the like are being held throughout the country, and a great many of them are being promoted and sponsored by the educational film distributors themselves.

College classes in visual education are becoming increasingly popular. A great many colleges and universities are offering credit courses in this subject, especially in their summer schools where public school teachers come to continue their studies. Also general visual education conferences are being held in conjunction with summer school activities so that teachers can have a chance to learn more about correct film utilization.

Some educational film distributors, aside from their annual catalogue listing of films, are finding the regularly published bulletin effective in publicizing their services and in educating their exhibitors in the proper utilization of the teaching film. The bulletins usually take the form of a periodic newsletter, each edition dealing with a specific problem such as that of using the film effectively, caring for the projector, and elimination of film damage.

This brings us to the consideration of film damage. Most distributors admit that this is one of the most provoking of all problems connected with film library work. Carelessness on the part of the projectionist is the underlying reason for the majority of cases of film mutilation. A great many schools are in the habit of training students to operate the motion picture projectors. This practice, for the most part, has proved successful, but there are times when the students, and even the faculty members who operate projectors, become careless, possibly not realizing the value of the film that is being threaded

improperly. Now and then the projectionist, to protect himself, will claim that the film was damaged when he received it. Cases of this kind are individual problems in themselves, and sometimes the distributor will be obliged to make good the damage himself, knowing that he cannot afford to incur the ill will of the exhibitor.

There are many cases, however, when the school or organization damaging the film is ready and willing to pay for the replacement. Actually, there are probably more cases of this kind than of the other. Despite this willingness on the part of the one who damages the film, it is still an unpleasant task when the distributor is forced to submit a statement of replacement costs to the exhibitor.

Now and then damage is caused when the film is projected by inexperienced operators. There is, of course, no excuse for a situation of this kind. If enough organizations are required to pay, and pay the full costs, for film damage caused by careless or inexperienced operators, the future question of film mutilation may take care of itself.

Another reason for film damage, especially during the war years when projectors are difficult to acquire and when servicing facilities are taxed, is the defective projector. Too many projector owners are failing to have periodic projector check-ups, and too many of them are continuing the use of their projectors knowing full well that the machines are defective. Once again the distributor in the field can render a service by keeping the film users projector-conscious.

Nor can we assume that film damage is always the fault of the exhibitor himself. Careless inspection on the part of the distributor many times causes film damage which would not have otherwise happened. One damaged sprocket hole left unrepaired by an inspector can be the cause of extended damage the next time the film is projected, and in cases of this kind the next exhibitor is held responsible sometimes without reason. All of which proves that the distributor himself should always maintain the highest standards of film inspection.

The selection and acquisition of film material to be distributed is another major problem of the educational film librarian. It can safely be said that all educational film distribution up to the present time has had to be considered somewhat of a pioneering effort since the use of films in classroom teaching is a comparatively new technique for most teachers. The instructors themselves, not knowing much about the technique, have not been able to formulate in their own minds

the type of material they really need. As a result, the film producers have had to determine the material that would be of most value. It must be admitted, however, that the producers of educational films have, considering the lack of research material, done a good job, especially in some fields. Their major problem has been one of supplying material for a demand which, in itself, has not yet been too clearly defined. The few studies that have been made have been a help, but the whole field has been too new to expect the producers to accomplish much more than has been done.

During the pioneering stages of any development, materials are naturally costly. Such has been true in the educational film field, and this one fact has held back the advance of the use of classroom films to some extent. Because of the high cost of individual classroom film subjects, the demand for them has, in many cases, exceeded the ability to pay for them. The producer of the future who honestly wants to make the best contribution to the advancement of visual education will consider seriously the question of original print costs. He will do well to consider the possibility of operating successfully through mass production of low-cost material rather than that of keeping the cost of individual film subjects high because of a limited number of sales. If, after the war, visual materials and equipment are made available at a cost within the range of the average educational organization, we may well expect some revolutionary trends.

For obvious reasons educational film producers have produced much better films in some fields of teaching than they have in others. Good films in the physical sciences, for instance, have been much more plentiful than in some other fields. The reason for this is clear: biology, chemistry, physics, and the other related subjects have proved more easily adaptable to logical film treatment. This does not mean, however, that we do not need more and more films in the physical sciences. But it does mean that there is a striking dearth of material in most of the other teaching fields.

Mathematics, for example, should come in for much interesting future film production. There are almost no films in this subject at the present. The same is true of literature and the languages. Films are also needed in the social sciences, and these should not offer production problems too difficult for many producers to handle well. Films in history, sociology, and economics will easily lend them-

selves to classroom projects and discussion. There is also a great future for the documentary film on international relations and political science. Even we, who already believe so much in the power of the film as a teaching tool, will be amazed at what the film can do in the future to dispel the chaotic conditions that now exist simply because man does not know and understand his next-door neighbor.

TECHNICAL NEWS

The items appearing in this section were submitted February 16, 1945, by members of the Technical News Committee, who welcome and will consider items of current technical interest from any member of the Society.

Additional information concerning these items, or the equipment and processes discussed, may be obtained by communicating with the General Office of the Society, Hotel Pennsylvania, New York 1, N. Y.

COLOR

Technicolor Motion Picture Corp.—Technicolor is now making 16-mm prints of current studio feature length Technicolor pictures for distribution to the armed forces through the War Activities Committee. These prints are made both by the Kodachrome procedure and by the Technicolor imbibition procedure, the latter being a relatively new development for 16 mm which yields prints approaching the high Technicolor 35-mm quality.

SOUND

E. I. du Pont de Nemours & Co.—The Photo Products Dept. of the duPont Company has recently introduced 2 new fine-grain sound films, types 232 and 236. Both are designed to fit specific needs which have arisen in connection with the change-over from UV to white-light printing of variable-density sound negatives in some of the studios.

Type 232 is a low contrast, fine-grain positive which, white-light printed and processed in standard positive developing solutions, gives very closely the same effective contrast as obtained with fine-grain release stock, UV printed and similarly developed. Current studio practice is to keep production sound negatives at high gamma levels and to employ type 232 for daily and dubbing prints.

In comparison with UV prints on fine-grain release positive, type 232 (white-light printed) shows improved signal-to-noise ratio, equal latitude, and the same or less intermodulation distortion.

Type 236 is a fine-grain recording film with speed sufficiently increased over that of type 226 to meet the exposure requirements for low gamma release negatives.

Intermodulation and listening tests comparing type 236, white-light printed, and type 226, UV printed, with fine-grain release positive, indicate that both combinations are closely equivalent in signal-to-noise ratio, distortion, latitude, and frequency response.

White Light vs. Ultraviolet.—Two changes have recently taken place in the handling of most density sound recording products, namely: New fine-grain recording films have been made available by the film manufacturers for white-light printing and the ultra-violet licenses, previously available to most density recording studios, have been canceled.

During the period when sound recording activity was confined to the old "coarse grain" film recording stocks, a slight improvement was effected through the use of ultraviolet light in the printing of the sound record. This quality improvement was later gained through the use of fine-grain films, although ultraviolet light was continued in use in order to gain a lower effective gamma for a given time of film development. The newly developed fine-grain sound recording stocks give this result without the use of ultraviolet light and thus give the laboratories greater exposure latitude in their printing process.

STUDIO LIGHTING

The use of the relay condenser system for projecting process plates is rapidly gaining ground in the Hollywood studios. Previously, one of the bottlenecks in background projection was the inability to obtain sufficient screen light to fill a screen 20 ft wide or larger. Screen light was limited to approximately 12,000 lumens with the straight condenser-type system. At present the relay condenser system, with carbons operating at 225 amp, is capable of delivering as much as 35,000 lumens for straight production from one unit.

Experimentally it has been proved that increases in screen light can be effected by increases in the power of the light source and the limiting factor at present is a suitable means of cooling the aperture.

CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

The editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D. C., or from the New York Public Library, New York, N. Y., at prevailing rates.

American Cinematographer

25 (Nov., 1944), No. 11	
The New Auricon Automatic-Parallax View-Range Camera Finder (p. 368)	W. G. C. BOSCO
Reproduction of Color Sound Records (p. 370)	R. Görisch and P. Görlich
High-Speed Cameras (p. 373)	E. D. EYLES
25 (Dec., 1944), No. 12	
16-Mm Color to 35-Mm Black-and-White (p. 407)	C. H. DUNNING
New Place for Aerial Camera (p. 425)	

Electronic Engineering

17 (Dec., 1944) No. 202	
Swiss Television Large Screen Projector (p. 294)	T. M. C. LANCE

International Photographer

16 (Dec., 1944) No. 11	
Shift of Television Standards Creates Problem (p. 11)	T. ALLAN
Television Topics (p. 14)	W. S. STEWART

International Projectionist

19 (Nov., 1944), No. 11	
Projectionists' Course on Basic Radio and Television—Pt. 5 (p. 20)	M. BERINSKY
19 (Dec., 1944), No. 12	
Making Wiring and Schematic Diagrams: Advanced Steps (p. 7)	L. CHADBOURNE
Importance of 16-Mm Film in Television (p. 11)	J. FLORY
Projectionists' Course on Basic Radio and Television—Pt. 6 (p. 14)	M. BERINSKY
The Effect of Lamp Filament Position on Projection Screen Brightness Uniformity (p. 20)	M. G. TOWNSLEY
Standards for Theater Television (p. 29)	H. GOLDIN

Motion Picture Herald (Better Theaters Section)

157 (Dec. 9, 1944), No. 10

Historical Correction (p. 12)

A Device to Prevent the Crushing of Film Edge (p. 22)

T. RAMSAYE

T. KULKA

Radio News

33 (Jan., 1945), No. 1

Television Is Coming to the Smaller Cities (p. 29)

Television in Great Britain (p. 32)

Television—for Industry and Home (p. 53)

A. C. LESCARBOURA

L. LADEN

W. BALTIM

57th SEMI-ANNUAL TECHNICAL CONFERENCE OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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HOLLYWOOD-ROOSEVELT HOTEL
HOLLYWOOD, CALIFORNIA
MAY 14-18, 1945

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16-mm..... H. W. REMERSHIED, *Chairman*

HOTEL RESERVATIONS AND RATES

The Hollywood-Roosevelt Hotel management extends the following per diem room rates, European Plan, to SMPE members and guests attending the Fifty-Seventh Technical Conference:

Room with bath, one person.....	\$4.40
Room with bath, two persons, double bed.....	5.50
Room with bath, two persons, twin beds.....	6.60-7.70

Note: There will be no parlor suites available at the hotel during the conference dates.

Special Notice

Owing to the acute housing situation in Hollywood, the hotel management can assign the conference only a limited number of rooms for Eastern and Midwestern members attending this Conference. Therefore *no room reservation cards* will be mailed to the membership as heretofore. Accordingly, you are requested to make room reservations *direct* with Stewart H. Hathaway, Manager of the Hollywood-Roosevelt Hotel, Hollywood, California, not later than April 10. *No rooms will be assured or guaranteed at this hotel unless confirmed by Mr. Hathaway, which are subject to cancellation prior to May 10.*

Your Conference Chairman has arranged with the Mark Hopkins Hotel management in San Francisco, California, to provide accommodations for members who will visit this city while on the West Coast. Accordingly, reservations should be made *direct* with R. E. Goldsworthy, Manager of this hotel, at least 2 weeks in advance of your arrival in San Francisco. When making reservations, advise the management that you are a member of the SMPE.

RAILROAD AND PULLMAN ACCOMMODATIONS

Eastern and Midwestern members of the Society who are contemplating attending the Conference in Hollywood should consult their local railroad passenger agent regarding train schedules, rates, stopover privileges, and Pullman accommodations at least 30 days prior to leaving, otherwise no accommodations may be available.

REGISTRATION

The Conference registration headquarters will be located on the mezzanine floor of the hotel near the Studio Lounge where all business and technical sessions will be held during the Conference. Members and guests are expected to register. The fee is used to help defray Conference expenses.

TECHNICAL PAPERS

Members and others who are contemplating the presentation of papers can greatly assist the Papers Committee in their early program assembly, and scheduling in the final program, by mailing in the title of paper, name of author, and a *complete manuscript* not later than *April 20* to the West or East Coast chairman of the Papers Committee, or to the Society's New York office.

CONFERENCE LUNCHEON

The usual Conference Get-Together Luncheon will be held in the Terrace Room of the hotel on Monday, May 14, at 12:30 p.m. The luncheon program will be announced later.

Members in Hollywood and vicinity will be solicited by a letter from S. P. Solow, Secretary of the Pacific Coast Section, to send remittances to him for Conference registration fee and luncheon tickets. Checks or money orders should be made payable to W. C. Kunzmann, Convention Vice-President, and not to the Society.

INFORMAL DINNER-DANCE

The Fifty-Seventh Semi-Annual Dinner-Dance and social get-together of the conference will be held in the California Room of the hotel on Wednesday evening, May 16, at 8:30 p.m.

A social hour with your Board of Governors will precede the Dinner-Dance between 7:30 p.m. and 8:30 p.m. in the Terrace Room. (Refreshments)

Table reservations may be made and tickets procured for the Dinner-Dance during the week of May 6 from W. C. Kunzmann, Convention Vice-President, Hollywood-Roosevelt Hotel, or at the registration headquarters not later than noon on *May 15*. All checks or money orders should be made payable to W. C. Kunzmann, Convention Vice-President, and not to the Society.

Because of strict food rationing and a shortage of hotel labor, your committee must know in advance of the Luncheon and Dinner-Dance the number of persons attending these functions in order to make the necessary hotel arrangements. Therefore your cooperation is solicited.

LADIES' REGISTRATION

There will be no ladies' reception committee or hostess during the Fifty-Seventh Technical Conference. However, all ladies are requested to register at the registration desk to receive identification cards for admittance to the *deluxe* motion picture theaters on Hollywood Boulevard in the vicinity of the hotel. Ladies are welcome to attend the Luncheon on May 14 and the Dinner-Dance on May 16.

MOTION PICTURES

The Fifty-Seventh Technical Conference recreational program will be announced later when arrangements have been completed by the local committee.

Conference identification cards issued only to registered members and guests will be honored through the courtesy of the following *deluxe* motion picture theaters on Hollywood Boulevard:

FOX WEST COAST GRAUMAN'S CHINESE AND EGYPTIAN
HOLLYWOOD PARAMOUNT
HOLLYWOOD PANTAGES
WARNER'S HOLLYWOOD THEATRE

*Tentative Program**Monday, May 14, 1945***Open Morning**

- 10:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Luncheon tickets.
12:30 p.m. *Terrace Room:* SMPE Get-Together Luncheon. (Speakers)
2:00 p.m. *Studio Lounge:* Opening Conference.
Business and Technical Session.
8:00 p.m. *Studio Lounge:* Evening Session.

*Tuesday, May 15, 1945***Open Morning**

- 10:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Dinner-Dance tickets.
2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.

Wednesday, May 16, 1945

- 9:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Dinner-Dance tickets.
9:30 a.m. *Studio Lounge:* Morning Session.

Open Afternoon.

- Note:* Registration headquarters will be open on the afternoon of this date for those desiring to make final arrangements for Dinner-Dance tables and accommodations.
7:30 p.m. *Terrace Room:* A social hour with your Board of Governors preceding the Dinner-Dance. (Refreshments)
8:30 p.m. *California Room:* The Fifty-Seventh Semi-Annual Dinner-Dance and social get-together. Dancing and entertainment.

*Thursday, May 17, 1945***Open Morning.**

- 2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.

*Friday, May 18, 1945***Open Morning**

- 2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.
Adjournment of the Fifty-Seventh Semi-Annual Technical Conference.

IMPORTANT

The Eastern and Midwestern members who plan to attend the 1945 Spring Conference in Hollywood are again cautioned to check railroad and Pullman accommodations, and make hotel room reservations at least 30 days prior to leaving for the West Coast.

Owing to the strict food rationing and hotel labor conditions existing on the West Coast, your arrangements committee requests that Luncheon and Dinner-Dance tickets be procured prior to the dates of these functions so that accommodations can be provided accordingly.

W. C. KUNZMANN
Convention Vice-President

SOCIETY ANNOUNCEMENTS

ATLANTIC COAST SECTION MEETING

Julien Bryan, noted motion picture producer and lecturer, described his technique of motion picture production and methods of operation to a large gathering of members and guests of the Atlantic Coast Section on January 17. Mr. Bryan has been actively engaged in various phases of photography since 1916 when he made a series of 600 stills while attached to the French Army at Verdun.

Since 1930 Mr. Bryan has devoted his attention to motion pictures and has traveled extensively in Europe and South America. Arriving in Poland in 1939 when most news reporters were leaving or had left, he secured some of the first motion picture footage of the present war. These were seen in America as "Siege."

Mr. Bryan has recently completed a series of 21 documentary films on South America for the Office of the Coordinator of Inter-American Affairs, several of which were shown to the audience in the RCA Studios, New York.

EMPLOYMENT SERVICE POSITIONS OPEN

Young man with several years' experience in Motion Picture Camera and Projector design. Must have mechanical background with a knowledge of motion picture industry requirements. Write or telephone for interview. Akeley Camera, Inc., 175 Varick St., New York 14, N. Y. WALKER 5-7954.

Optical engineer's assistant. Acquainted with optical laboratory routine, ray tracing and similar problems in related scientific fields. Reply to Optical Engineering Department, DeVry Corporation, 1111 Armitage Ave., Chicago 14, Ill.

POSITION WANTED

Engineer desires position with manufacturer or theater circuit supervising construction, maintenance, or operation. Sixteen years' experience. For details write P. O. Box 710, Chicago, Ill.

Notices from business organizations for technical personnel and from members of the Society desiring technical positions which are received before the 15th of the month will appear in the JOURNAL of the following month. Notices should be brief and must give an address for direct reply. The Society reserves the right both to edit or reject any notice submitted for publication.

We are grieved to announce the death of Lieut. Morgan L. Hobart, USNR, Associate member of the Society, on February 23, 1945.

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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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(The Society is not responsible for statements of authors.)

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*Term expires December 31, 1945. †Chairman, Pacific Coast Section.
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FLEET PROCESSING OF 16-MM GUN CAMERA AND COMBAT FILMS*

L. M. DEARING**

Summary.—Processing formulae and methods for 16-mm gun camera and combat films have been set up for military use. They are designed to operate under all conditions of temperature found in the field and on all types of Navy processing equipment including buckets, rack and tanks, Smith-type outfits and continuous processing machines of the Houston type. Instructions for development to either a negative or a reversal image are included. This work has led to procurement of standardized 16-mm Universal films of speed index 50 and 100 which can be processed either to negative in a negative developer or to reversal in a single standard set of reversal formulae.

The reversal processing formulae will give usable quality on all 16-mm Universal films as well as on most 16-mm reversible films made by different manufacturers. One formula modification is required for some films (an addition to the first developer). Either a fogging redeveloper (sulfide) or "re-exposure" followed by a second MQ developer is used to develop the reversal (positive) image depending upon the equipment used. It is believed that these Universal films and standardized processes will do much towards removing the confusion heretofore encountered by widespread military activities using 16-mm films.

Today the U. S. Navy processes 16-mm films throughout the world—at shore stations, on board ships, and at the advanced bases of combat areas. Experience has shown that, although in many cases a negative image will suffice, often the direct positive image of reversal processing is needed for quick evaluation. In order that the many photo labs of the Navy can attain satisfactory results, films coming to them should be adaptable to either negative or reversal processing and, moreover, all the 16-mm films regardless of the source should process together through a single set of negative or of reversal

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Lieutenant Commander, USNR, U. S. Naval Photographic Science Laboratory, Anacostia, D. C.

formulae. Up to the present no suitable standards have been set up for 16-mm reversible films with the result that films from different manufacturers required entirely different formulae and methods. This fact has caused serious difficulty in the military use of these films.

During the past year the U. S. Naval Photographic Science Labora-

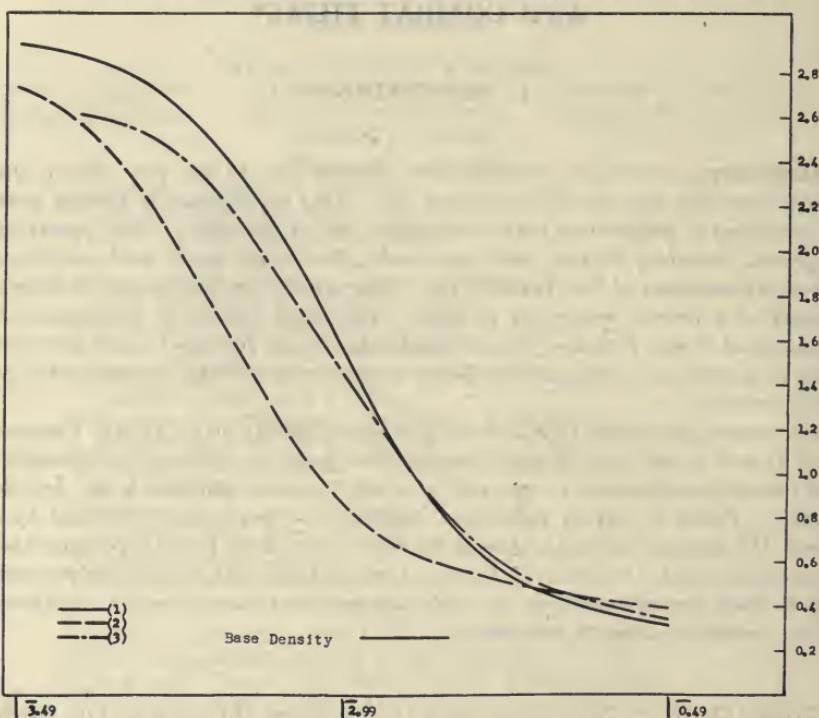


FIG. 1. Sixteen-millimeter Navy Universal films through Navy reversal process: (1) Universal speed group 50—Navy re-exposure process; (2) Universal speed group 100—Navy re-exposure reversal process; (3) Universal speed group 50—Navy sulfide reversal process.

tory under the direction of the Photographic Division of the Bureau of Aeronautics has done intensive processing development work on reversal films made by 3 different manufacturers—General Aniline and Film Corporation (Ansco Division), E. I. duPont de Nemours and Company, and the Eastman Kodak Company. These manufacturers extended much aid to the Navy during the course of this work. The aim of this work was to devise a set of reversal processing formulae suitable for packaging that would give satisfactory or usable

results on duPont Pan 314 and Superior 2, type 301, Ansco Hypan and Triple-S, and Eastman Super X and Super XX reversible films. A further aim was to set up specifications for so-called Universal 16-mm films which could be processed to a negative or reversal image in the standard processes by any activity.

After considerable experimentation a so-called Navy Standard

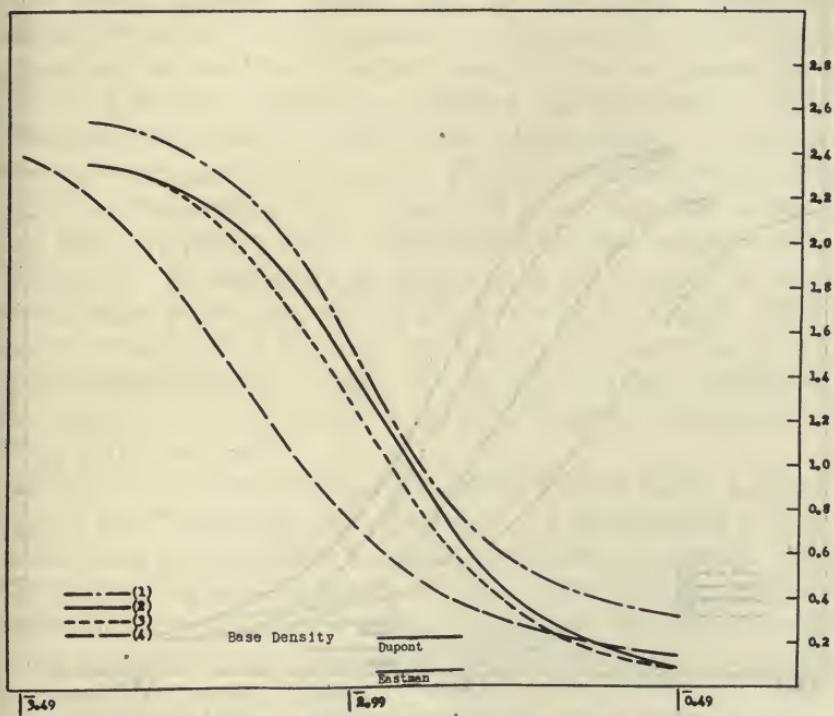


FIG. 2. Commercial 16-mm films in the Navy re-exposure reversal process: (1) duPont Pan 314—Navy process; (2) Eastman Super X (5256)—Navy process; (3) Eastman Super X (5256)—Manufacturer's process; (4) Eastman Super XX (5261)—Navy process.

Reversal Process was adopted which gives usable results on most of the above 16-mm reversible films and is particularly suited to the varied conditions encountered in military use. With this as a basis specifications for packaged chemical kits for reversal processes and specifications for "16-mm Universal" (negative or reversal) films have been proposed for use in the Navy and other branches of the military services.

The 16-mm Universal films are designed primarily for use in gun camera and combat photography, and ease of handling and processing have been incorporated as far as is possible and compatible with good photographic quality. They are supplied on gray base safety support in speed groups 50 and 100, and can be processed to either a

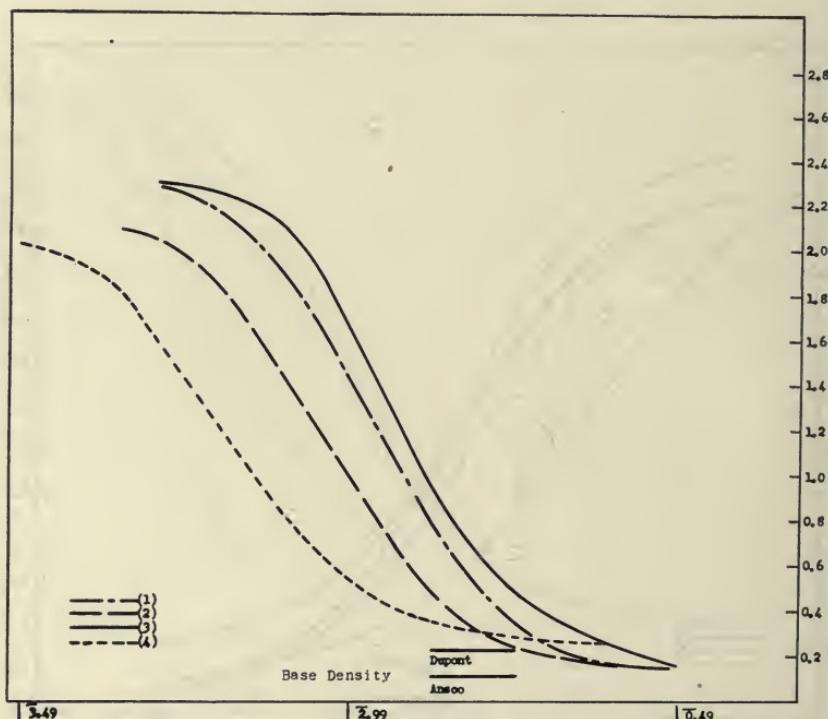


FIG. 3. Navy re-exposure reversal process as modified for other commercial 16-mm films (5 gm per liter of sodium thiocyanate added to the first developer—RN-1): (1) Ansco Hypan (292)—Navy process modified; (2) Ansco Triple-S (293)—Navy process modified; (3) Ansco Hypan (292)—Manufacturer's process; (4) duPont Pan (301)—Navy process modified.

negative or a reversal image. For best quality speed group 50 is recommended, as the speed group 100 films show marked increase in graininess and loss of definition. In general the results that can be obtained with these films compare very well with the best commercial 16-mm films, both negative and reversible, available at the present time. Recently 3 manufacturers have produced 16-mm Universal films of speed group 50, and a fair speed group 100 film is available.

Using the Navy packaged reversal formulae, all the 16-mm Universal films, duPont 314, Eastman Super X and Super XX reversible films can be processed together; and by making an addition of sodium thiocyanate to the first developer, Ansco Hypan and Triple-S and duPont 301 can also be handled. This process is simple, fast, and relatively foolproof.

The formulae are packaged in 2 different kits: one, the "Navy Re-exposure Reversal Process" and the other, the "Navy Sulfide Reversal Process." Both processes are identical up to the point of developing the positive or reversed image. The re-exposure reversal process is for use on continuous machines having printing lamps for re-exposure or flashing followed by an *MQ* developer to develop the reversal image, and a fixing bath. The Navy sulfide reversal process is for hand processing such as rack and tank, loose film in buckets, and other equipment where re-exposure of the film is inconvenient or impossible. All stages of this process with the exception of the first development go to completion in about one minute's time. With the sulfide process only 5 solutions are needed and the wet stage can be accomplished in about 15 min. The reversal image is developed up as sepia-toned silver sulfide in a kodalk-sulfide redeveloper. No fixing bath is required.

Both processes are especially designed for and easily adapted to field or fleet conditions and equipment. A prehardener is used to toughen the film and allow for high temperature processing. It also holds down fog and improves definition and quality. The other stages of the processing are similar in action to the conventional reversal process with the possible exception of the sulfide redeveloper. The steps are for both types:

Re-exposure Process
Prehardener
First Developer
Rinse
Bleach Bath
Clearing Bath
Flash Re-exposure
Second Developer
Fix
Wash

Sulfide Process
Prehardener
First Developer
Rinse
Bleach Bath
Clearing Bath
Sulfide Redeveloper
Wash

The prehardener, formula *UH-1*, and the first developer, formula *RN-1*, are rather unusual in formulation and the quality of the final image is almost entirely dependent upon them. The prehardener,

in addition to the effects mentioned in the preceding paragraph, gives better reversal high-light quality and conditions the film so that the rate of bleaching and redeveloping is increased. The first developer, *RN-1*, is a caustic *MQ* developer containing sodium thiocyanate and having an unusually high ratio of hydroquinone to elon, more than 20 to 1. This developer has a long life, changes little in its rapid

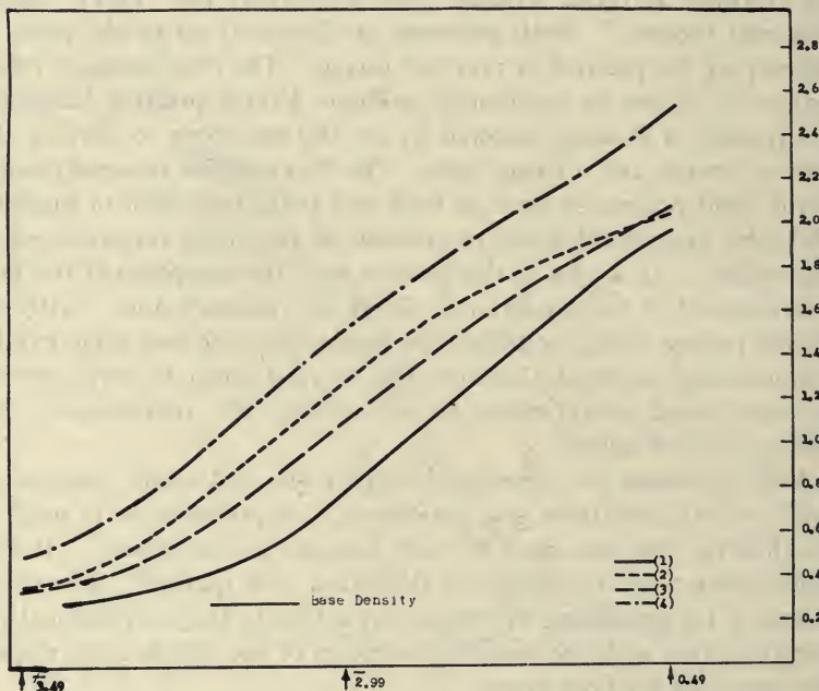


FIG. 4. Sixteen-millimeter Navy Universal films processed to a negative: (1) Universal speed group 50—D-76, 4 min, 20 C; (2) Universal speed group 100—D-76, 6 min, 20 C; (3) Eastman 16-mm Negative (5240)—D-76, 7 min, 20 C; (4) Eastman 16-mm Negative (5242)—D-76, 20 min, 20 C.

action up to 10 sq ft of film per liter, and gives to the films high reversal speed and good exposure latitude. It can be diluted up to 50 per cent and used at longer developing times, 6 min at 68 F with little change in final image quality except for a slight decrease in contrast. The processing times as set up in the following sections are designed for use with maximum re-exposure (complete fogging of the reversal image) which is considered easier for inexperienced personnel to con-

trol. Controlled re-exposure can be used provided that the degree of first development is decreased.

In the sections which follow information is given as to the processing techniques and times required for different types of Navy processing equipment: rack and tank, the Houston *K-1A* and *K-2A* machines, and the Smith 16- and 35-mm developing outfits. In the appendix, the formulae are given using the Navy formula numbers as referred to in the text. In each section the processing methods as used in the Navy are outlined for developing various 16-mm films such as negative films of speed group 25 and 100 to a negative, Universal films of speed group 50 and 100 either to a negative or to reversal, and commercially available reversible films to negative or to reversal as applicable. The sensitometric results obtained with these films and processes are illustrated in Figs. 1 through 4.

It is recognized that the methods and portable equipment used by the Navy for fleet and air station processing are not comparable to those needed by commercial producing organizations. However, these reversal processing methods are believed to be of general interest to the 16-mm film producers and might be found useful in this field as well.



FIG. 5. Loading 16-mm rack for 8 × 10-in. cut film tanks.

PROCESSING OF 16-MM FILMS BY THE "RACK AND TANK" OR "BUCKET" METHOD

The hand processing methods of this section are used on small ships and stations or advanced bases where portable machines are not available. They apply to "rack and tank" and "Steinman reel"

equipment or even to a "bucket." The present Steinman reels do not withstand the bleach of the reversal process very well and have to be tested with this solution prior to use. Good results for either negative or reversal processing may be obtained with rack equipment if due care is maintained by the operator. Physical defects such as scratches are to be expected when using the "bucket" process and before long such crude methods will be unnecessary even in the most advanced combat areas.

Rack and Tank.—Any suitable rack and tank can be used. Where space requirements are at a premium a compact design similar to the so-called "Navy rack" will give good results. This rack consists of a folding framework,



FIG. 6. Sixteen-millimeter rack for 8 X 10-in. cut film tanks loaded with 16-mm film.

Bucket Process.—In this process the spooled film is unwound first into the prehardener solution (Fig. 7). The resulting film coils are loosened by hand while in the prehardener. The film is transferred from one solution to another as a loose mass, Fig. 8, and gently agitated by hand. Rubber gloves are recommended and care must be exercised to avoid scratching the film, but fair results may be obtained if the prehardener is used. After washing, the film is untangled, squeegeed, and hung up to dry or dried on a rack or drum.

Negative Processing.—For field processing with hand equipment, the use of the prehardener *UH-1* is recommended even at normal temperatures to reduce scratches and other physical defects. The

which will hold about 110 ft of 16-mm film, designed to fit a standard 8 X 10-in. sheet film developing tank (see Figs. 5 and 6). The film is wound on the rack, starting on the inside posts, then by raising into position a new tier of posts as each preceding tier is filled with film, the entire rack is filled with film. Agitation is obtained by lifting the rack several inches out of the solution and lowering it to the bottom of the tank several times at intervals while processing. The film is taken off the rack for drying.

time required for the prehardener is 2 to 4 min and the negative development time is increased 10 per cent over that used without the prehardener. The remainder of the negative processing is conventional: Negative and Universal films for gun camera film training and scoring purposes can be developed in *D-76* or *DK-50* for 5 to 10 min depending on the contrast desired. For negatives from which 16-mm motion picture positive prints are to be made, the contrast can be controlled so that a gamma of about 0.70 is obtained. Universal film speed group 50 should be exposed as if it were speed group 25 when it is to be processed to a low contrast negative.

Where high temperature processing is necessary, the use of a prehardener containing relatively high amounts of antifoggant has been successful. *UH-1* requires an addition of the antifoggant, 6-nitrobenzimidazole nitrate (0.3 gm per liter) for temperatures above 80 F. It is then roughly equivalent to the recently published prehardener, Kodak *SH-5* of the Eastman Kodak Company.¹ Table 1 is used as a time-temperature guide for negative processing with rack and tank. Agfa-Ansco Hypan and Triple-S Pan are not satisfactory when developed to a negative owing to the presence of a brown undercoat which is not removed during negative processing.

Reversal Processing.—The formulae for the Navy sulfide reversal process are now being packed in kits, 2½-gal size, for military use. Solutions for this process can also be mixed from bulk chemicals according to the formulae given in the last section. The steps for processing 16-mm film on the rack-and-tank or in the bucket process at 70 F, with agitation every 30 sec are as follows:



FIG. 7. Sixteen-millimeter "bucket" process—winding dry film into prehardener solution.

(a) Prehardener, Formula <i>UH-1</i>	2 min
(b) First Developer, Formula <i>RN-1</i> (diluted 1:1)	5½ min
(c) Rinse	1 min
(d) Bleach, Formula <i>RB-1</i>	1 min
(e) Rinse (optional)	30 sec
(f) Clear, Formula <i>RC-1</i>	1 min
(g) Redevelop, Formula <i>RS-1</i>	1 min
(h) Wash	5 min
(i) Aerosol Rinse (optional)	1 min
(j) Squeegee and Dry	

As outlined above, this process will handle 16-mm Universal gray base films, speed group 50 and 100, duPont 314, and Eastman Super X (5256) and Super XX (5261). Agfa Reversal Hypan, Triple-S Pan, and duPont 301 can be processed by adding 5 gm per liter (or 1-2 oz, 70 gm per gal) of sodium thiocyanate to the first developer, formula *RN-1*, used full strength. Developing times and all other conditions will remain approximately the same as for Universal films.

TABLE 1
Time-Temperature Table for Processing of 16-Mm Films to a Negative

Film	Developer	Developing time with no prehardener at temperature degrees F			Developing time using <i>UH-1</i> prehardener plus 0.3 gm per liter of 6-nitrobenzimidazole nitrate at temperature degrees F			
		70	75	80	85	90	100	110
Negative Speed Group 25	D-76	7	5½	4½	5	4	2½	...
Negative Speed Group 100	D-76	15	11	9	10	8	5	3
Universal Speed Group 50	N-2	5	3¾	3	3¼	2½	1½	...
Universal Speed Group 50	D-76	4	3	...	...	...	...	...
Universal Speed Group 100	D-76	7½	5½	4½	5	4	2½	...
Super X (5240)	D-76	7½	5½	4½	5	4	2½	...
Super XX (5242)	D-76	15	11	9	10	8	5	3
DuPont 314	D-76	5½	4	3	3¾	3	2	...
Agfa Supreme	D-76	15	11	9	10	8	5	...
Super XX (5261)	D-76	7½	5½	4½	5	4	2½	...
Super X (5256)	N-2	5	3¾	3	3¼	2½	1½	...

The chemical reactions following the first development go to completion and little attention other than thoroughness and ordinary care is required in completing this part of the process. White lights may be turned on after the film has been placed in the bleach. Since the final image quality is dependent upon the degree of development of the *negative* image in the first developer, time and temperature recommendations for the first development must be followed closely.

Usable reversal results may be obtained with temperatures as high as 110 F if the following recommendations for changes in the prehardener and times in the first developer are followed. Table 2 applies to Universal films, although some of the commercial films withstand high temperature processing very well. The processing time in the other solutions is the same as for normal temperatures. However, the time in the prehardener can be increased and additional hardening obtained for films which show signs of softening or reticulation.

The solutions of the sulfide reversal process have a capacity of ap-

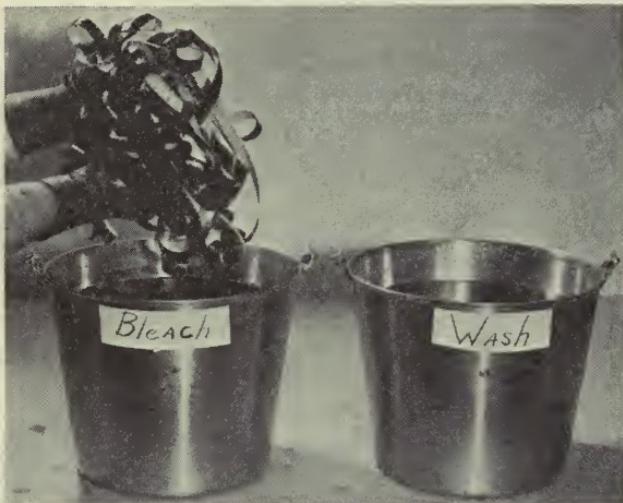


FIG. 8. Sixteen-millimeter "bucket" process—transferring mass of film from one solution to another, using rubber gloves.

proximately 1000 ft of 16-mm film per gal and the processing time of all solutions, except the first developer, usually will remain the same for used solutions during their life as for fresh solutions. The first development time can be increased by about 5 per cent for each 200 ft of film processed per gal to maintain quality and emulsion speed.

All instructions concerning this process point out the danger of hydrogen sulfide fumes should the acid bleach and sulfide redeveloper, RS-1, be mixed. Usually a separate sink is recommended or operators are cautioned to flush all bleach out of the sink before starting

the sulfide redevelopment and also advised not to store large quantities of photographic material in the same room.

NEGATIVE OR REVERSAL PROCESSING OF 16-MM FILMS ON THE HOUSTON DEVELOPER, TYPE K-1A, 16-MM MACHINE

The Houston Developer, Type *K-1A*, is a portable, continuous processing machine for 16-mm films suited for most large shore or

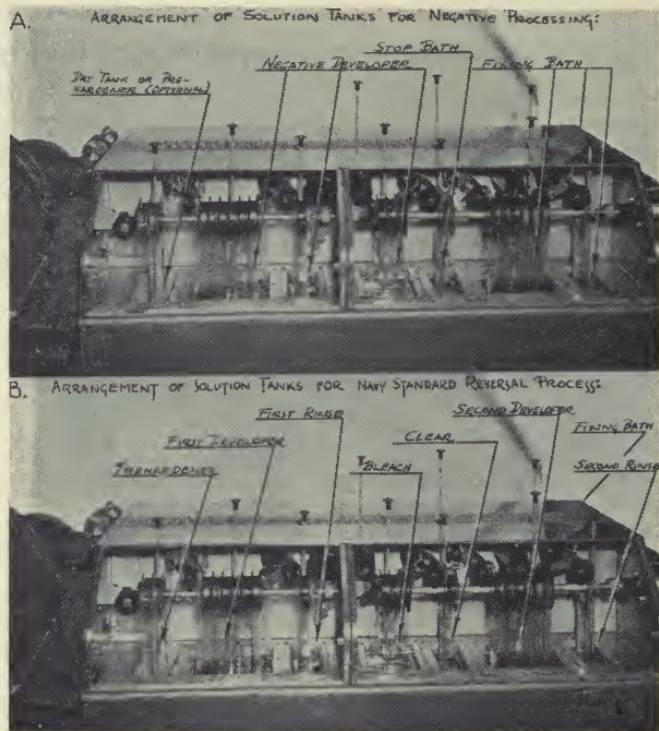


FIG. 9. Houston *K-1A* processing machine indicating solution arrangement for negative processing and for black-and-white reversal processing.

naval air station needs. It has a capacity of approximately 600 to 800 ft of processed and dried 16-mm film per hr. The *K-1A* machine (see Fig. 9) is designed as a complete unit, 76 in. long, 54 in. high, and 30 in. wide requiring only 3 connections: one electrical, one cold water, and one drain. The electrical power supply is 230 v, single-phase 50- or 60-cycle a-c. Light-tight feed film magazines and light-

tight covers over the processing tanks allow operation of the machine in a lighted room. A portable dark room 30 in. long, 16 in. wide, and 51 in. high complete with rewinds and light-tight loading bag

TABLE 2

Temperature of Solutions	Prehardener	Time of First Development in RN-1, Diluted 1:1
65 F	UH-1	7 min
70 F (recommended temperature)	UH-1	5½ min
75 F	UH-1	4 min
80 F	UH-1	3 min
85 F	UH-1	2 min
90 F	UH-1 plus 0.3 gm per liter or (18 gm per gal) of 6-nitrobenzimidazole nitrate)*	4 min
100 F	(same as for 90 F)	2½ min
110 F	(same as for 90 F)	1¾ min

* This is added as a 0.5 per cent solution, *i. e.*, 60 cc of 0.5 per cent solution of 6-nitrobenzimidazole nitrate per liter of prehardener.

openings, is used for loading exposed film in the light-tight magazines. The K-1A machine has 10 tanks of the following capacities:

Tank No.	Capacity of Tank		Film in Tank
	Liters	Gal	
1	12	3	16 ft
2	22	5½	37 ft
3	8	2	10½ ft
4	15	3¾	21 ft
5	8	2	10½ ft
6	22	5½	37 ft
7	8	2	5 ft
8	16	4	21 ft
9	28	7	47½ ft
10	8	2	5 ft
Drying Cabinet			55 ft

The range of machine speeds is from 7 to 15 ft per min.

Ordinarily, in this machine the first and second developer tanks are connected together through a tubing and a circulatory pump. For negative processing it is necessary to separate these 2 tanks and for best reversal quality, it is preferable to use a second developer which does not contain sodium thiocyanate, and is thus different from the first developer. Hence, for these processes the Navy dis-

connects the second developer tank from the recirculator pump and plugs the connecting pipes between the first and second developer tanks, so that the developer in the first developer tank only circulates and is separated from the second developer.

Negative Processing.—During negative processing in a lighted room both the tank covers on the solution side of the machine must be in place with the window in the second tank cover blackened out, and the printers, of course, turned off. The tanks are filled as follows:

Tank 1	Prehardener <i>UH-1</i> or Empty
Tanks 2, 3, and 4	Negative Developer
Tank 5	Stop Bath
Tanks 6, 7, and 8	Fixing Bath
Tank 9	Jet Spray Wash
Tank 10	Empty or with Aerosol Solution

Also see Fig. 9A for the order of the solution in the various tanks.

For gun camera scoring use where best quality is not essential, all 16-mm negative and Universal films can be developed to a negative in *D-76* developer at 68 F at a machine speed of 10 ft per min. If 16-mm prints are to be made at a later date and a contrast of about 0.70 is desired, the following negative developers and machine speeds are recommended:

TABLE 3

16-Mm Film	Film Speed Group	Developer	Machine Speed
Universal Films	50	<i>D-76</i>	15 ft per min
Universal Films*	50 (25)	<i>N-2</i>	12 ft per min
Universal Films	100	<i>D-76</i>	10 ft per min
Negative Films	25	<i>D-76</i>	10 ft per min
Negative Films	100	<i>D-76</i>	7 ft per min

* 16-mm Universal film, speed group 50, when developed to low contrast should be exposed in the camera at a speed index of 25 rather than 50. This film, so developed, gives excellent results. It has fine grain and exceptionally high definition.

Reversal Processing.—The re-exposure reversal process is best suited to the Houston Developer, Type *K-1A*, and these formulae are being packaged for the Navy in kits of a size to fit the tanks of this machine. They can be used for other types of equipment providing that the film can be re-exposed or flashed before second development. The solutions can also be mixed from bulk chemicals according to the formulae given in the last section.

The steps for this reversal processing of 16-mm Universal and other reversible films on the Houston *K-1A* machine are illustrated in Fig. 9B and listed below:

<i>K-1A</i> Tank Number	Solution
1	Prehardener, Formula <i>UH-1</i>
2	First Developer, Formula <i>RN-1</i>
3	Water Rinse
4	Bleach, Formula <i>RB-1</i>
5	Clear, Formula <i>RC-1</i>
Second Printing	
6	Second Developer, <i>RP-1</i>
7	Water Rinse
8	Fixing Bath—any hardening fixing bath suitable for motion picture films
9	Jet Spray Wash
10	Empty (Aerosol Rinse optional)

The recommended machine speed for 16-mm Universal films is 10 ft per min at 68 F. DuPont 314, Eastman Super X (5256) and Super XX (5261) can also be processed like the Universal films without modification although Super XX may require a slower machine speed for complete bleaching. Solution temperatures of 80 F can also be used and will increase the processing capacity by 50 per cent owing to the machine speed of 15 ft per min necessary at 80 F. AnSCO Reversal Hypan, Triple-S, and duPont 301 can be processed by adding 5 gm per liter or $\frac{1}{2}$ oz, 70 gm per gal of sodium thiocyanate to the first developer, formula *RN-1*. At 68 F the machine speed for these films is 7 ft per min.

The machine is operated with the second cover off over the bleach, clearing, second developer, and fixer tanks. If necessary, an incandescent bulb can be used in front of the second developer in addition to the regular printer, which is also turned on full to assure maximum printing.

The first developer is the only critical stage of the re-exposure reversal process. Since the final image quality is dependent upon the degree of development of the negative image in the first developer, machine speed changes are made in order to change the time of this solution. Changes of time in the other solutions have little or no effect on finished quality as long as they act to completion.

The prehardener, first developer, and second developer have a useful life of 2000 to 5000 ft of 16-mm film processed. The approxi-

mate useful life of the bleach and clearing baths is 2500 ft for Universal (speed group 50) films and 1000 ft for Universal (speed group 100) Kodak Super XX, Ansco Hypan, and Ansco Triple-S films. The ac-

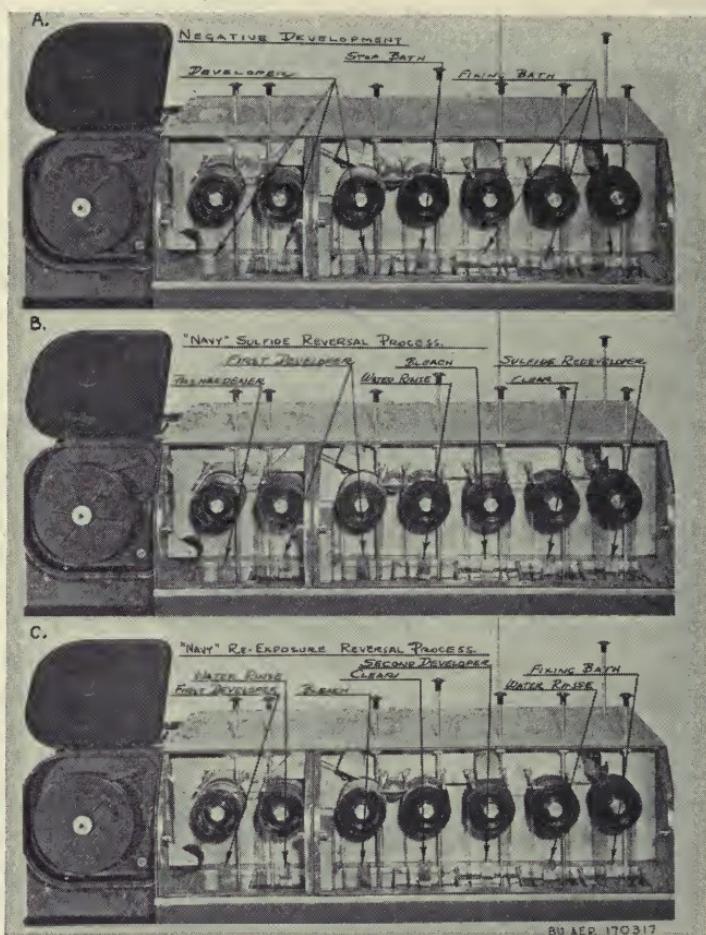


FIG. 10. Houston K-2A processing machine indicating solution arrangement for negative processing, for sulfide redevelopment, and for black-and-white re-exposure reversal processing.

tivity of the first developer will change somewhat during its life. This can be corrected by reducing the speed of the machine. In general it will be necessary to decrease the machine speed by only one or 2 ft per min for 5000 ft of film.

NEGATIVE OR REVERSAL PROCESSING OF 16-MM FILMS ON THE HOUSTON DEVELOPER, TYPE K-2A, 16-MM MACHINE

The *K-2A* machine gives results similar to those of the larger Type *K-1A* on negative or Universal-type films as processed to a negative. However, the sulfide reversal process is best suited to the *K-2A* for reversal processing of the Universal films and other reversible films. This gives a sepia image but otherwise the quality is similar to that of the larger machine.

The Houston Developer, Type *K-2A*, is a portable, continuous processing machine for 16-mm films, suitable for use on small air stations and aircraft carriers, and is similar to the *K-1A*. The capacity is approximately 400 ft of processed and dried 16-mm film per hr. It is a complete unit, 54 in. long, 25 in. wide and 46 in. high with 9 tanks of equal capacity (with exception of the wash tank which accommodates 20 ft of film instead of 16 ft); *i.e.*, $2\frac{1}{2}$ gal of 9.5 liters each, accommodating 16 ft of film in each tank. The range of machine speed for the *K-2A* is 4 to 7 ft per min, giving times ranging from 4 min to 2 min per tank. It also has a light-tight feed film magazine and light-tight covers over the processing tanks so the machine may be operated in a lighted room. A portable darkroom similar to the one for the *K-1A* machine is a standard accessory. Fig. 10 shows the machine with the covers off.

Negative Processing.—As with the *K-1A*, the tank covers on the solution side of the machine must be in place and the printers, of course, turned off during negative processing in a lighted room.

The tanks are filled as follows:

Tanks 1, 2, and 3	Negative Developer
Tank 4	Stop Bath
Tanks 5, 6, and 7	Fixing Bath
Tank 8	Jet Spray Wash
Tank 9	Empty or with Aerosol Solution

Also see Fig. 10A for the order of the solution in the various tanks.

For gun camera use 16-mm negative and Universal films can be

TABLE 4

16-Mm Films	Film Speed Group	Developer	Machine Speed
Universal Films	50 (25)	<i>N-2</i>	7 ft per min
Universal Films	50 (25)	<i>D-76</i> (2 tanks only)	7 ft per min
Universal Films	100	<i>D-76</i> plus 3 gm Kodalk per liter	7 ft per min
Negative Films	25	(same as above)	7 ft per min
Negative Films	100	(same as above)	5 ft per min

developed to negative in a single developer, which is *D-76* plus 3 gm of Kodalk per liter, at 68 F at a machine speed of 7 ft per min. For best photographic quality and if 16-mm prints are to be made at a later date, a contrast of approximately 0.70 can be obtained with the following developers and machine speeds at 68 F.

Réversal Processing.—The sulfide reversal process is recommended for the *K-2A* machine. Better definition is obtained on the sepia image of this sulfide process using a prehardener than on the black-and-white image of the re-exposure reversal process also described for this machine. In addition, this latter process requires slow machine speeds.

The packaged Navy sulfide reversal process, $2\frac{1}{2}$ gal size is used in the Navy on the Houston Developer, Type *K-2A*, as well as on the tank and Smith equipment described in other sections. The formulae are given in the last section.

The steps for sulfide reversal processing of gun camera or combat films on the Houston Developer, Type *K-2A* units are as follows (see Fig. 10B):

<i>K-2A</i> Tank No.	Processing Solution
1	Prehardener, Formula <i>UH-1</i>
2	Developer, Formula <i>RN-1</i>
3	Developer, Formula <i>RN-1</i>
4	Water Rinse or 4 per cent sodium bisulfate stop bath
5	Bleach, Formula <i>RB-1</i>
6	Clear, Formula <i>RC-1</i>
7	Redeveloper, Formula <i>RS-1</i>
8	Jet Spray Wash
9	Empty or Aerosol Rinse

The recommended machine speed for the above process is 7 ft per min at 68 F. The cover on the second compartment *must* be on when using this sulfide process. *No second printing is required.* Anasco Reversal Hypan, Triple-S and duPont 301 can be processed by adding 5 gm per liter or $\frac{1}{2}$ oz, 70 gm per gal of sodium thiocyanate to *RN-1* developer. At 68 F the machine time for these films is 5 ft per min. DuPont 314, Eastman Super X (5256) and Super XX (5261) can be processed like the Universal films without modification.

The Houston *K-2A* machine is equipped with electrical refrigeration and heating units for the purpose of controlling the solution temperature. However, good results can be obtained up to 80 F on the

K-2A machine when using the *UH-1* prehardener. In order to avoid overdevelopment it will be necessary to increase the speed of the machine and dilute the first developer, *RN-1*, one to one with water or use only one tank for first developer. Since the first developer is the only critical stage of the sulfide reversal process, and the final image quality is dependent upon the degree of first development, machine speed changes are made in order to change the time of this solution. Time changes on the other solutions have little or no effect on finished quality.

Useful Life of Solutions.—The prehardener, first developer, and sulfide redeveloper have a useful life of approximately 3000 ft of 16-mm film per $2\frac{1}{2}$ gal. The approximate useful life of the bleach and clearing baths on the Houston machines is 1500 ft for Universal (speed groups 50) films and 700 ft for Universal (speed group 100), Kodak Super XX, Ansco Hypan, and Triple-S films. Hence, after processing 700 ft of these latter films, or 1500 ft of Universal (speed group 50) film, the second package of bleach and clearing chemicals provided with each kit is put into use.

Re-exposure Reversal Process for Houston K-2A Machine—The Houston *K-2A* is equipped with second printers so that a re-exposure reversal process can be used. In this process no prehardener is used; only one tank is available for the first developer, and the machine is slowed down to 4 ft per min.

The steps of the Houston Developer, Type *K-2A* units for black-and-white reversal processing of Universal 16-mm films are as follows (see Fig. 10C):

<i>Machine Speed 4 Ft Per Min</i>	
<i>Temperature 68 F</i>	
Tank	Solutions
1	Developer, Formula <i>RN-1</i>
2	Water Rinse
3	Bleach, Formula <i>RB-1</i>
4	Clear, Formula <i>RC-1</i>
<i>Second Printing</i>	
5	Developer, Formula <i>RN-1</i> (without sodium thiocyanate)
6	Water Rinse
7	Fixing Bath
8	Jet Spray Wash
9	Empty or Aerosol Rinse

The above developing procedure can be made up from the Navy Standard Sulfide Reversal Processing Kit for the Houston *K-2A* machine. There are 2 packets of *RN-1* developer in this kit, one can be used for Tank No. 2 and one without sodium thiocyanate for Tank No. 5. Any hardening hypo fixer can be used in Tank No. 7. To assure maximum printing, when using this process the intensity rheostats should be turned as low as possible to provide maximum current to each lamp and the ground glass filters removed from the printers. The machine should be operated with the second cover off over the bleach, clearing, second developer, and fixer tanks. If necessary, an incandescent bulb can be used in front of the second developer in addition to the regular printer.

PROCESSING 16- AND 35-MM FILMS ON THE SMITH-TYPE PORTABLE MOTION PICTURE FILM DEVELOPING OUTFITS

In this type of equipment the film is wound back and forth between 2 reels under the processing solutions in the same fashion as for aerial film developing outfits. The photographic quality attainable is poorer than that obtained with other types of processing equipment such as the rack and tank or the Houston machines. This developing outfit is not recommended for films likely to be later reproduced. Although motion picture film processed on the Smith-type equipment is usually free from physical defects such as scratches and abrasions, nevertheless, uneven development, increased grain, flicker, and image defects are brought about by the infrequent change of developing solutions and long developing times necessary. However, it has the advantage of extreme portability and is of use on small ships where space is limited. Usable results for gun camera scoring films can be obtained with this equipment on either negative or Universal films processed to a negative. The reversal process described is suitable for Universal films of speed group 50 and for Eastman Super X 5256, which gives the best quality of any emulsion so far tested. Usable reversal results can also be obtained on Universal films of speed group 100, but other emulsions may give excessive flicker and image defects as processed to reversal.

The Smith 16- and 35-mm Film Developer (see Fig. 11) is so constructed that 2 reels lay flat and submerged in a tray containing the processing solution. The film is wound back and forth from one reel to the other below the solution surface. The machine is driven by a motor which reverses itself when the torque exceeds a given limit as

when the end of the film is reached, or it may be operated manually if power is unavailable. The top flange has 2 settings, one for 16-mm and one for 35-mm film. A later model has a 4-in. hub which gives better quality.

In operation the film is first fastened, then completely and tightly wound dry onto one reel with the emulsion side out. The outside end is then fastened to the empty reel. The film is introduced into the *first solution* by winding from the full dry reel onto the empty reel held submerged in the solution, the machine being held at an angle (see Fig. 11B). If a prehardener is used, the dry film can be put directly into the prehardener. Otherwise a water prebath should be used to wet the film before it enters the developer. All subsequent processing operations are performed with both reels submerged (Fig. 11C). The whole unit is moved from one tank to the next as processing proceeds. To obtain efficient washing the stream of wash water should flow forcefully against the submerged emulsion side of film. Although 200 ft of film can be processed at one time, better quality is obtained if only 100 ft is handled.

When splicing is required, the splices must be strong enough to withstand the maximum tension on the machine, and any unnecessary

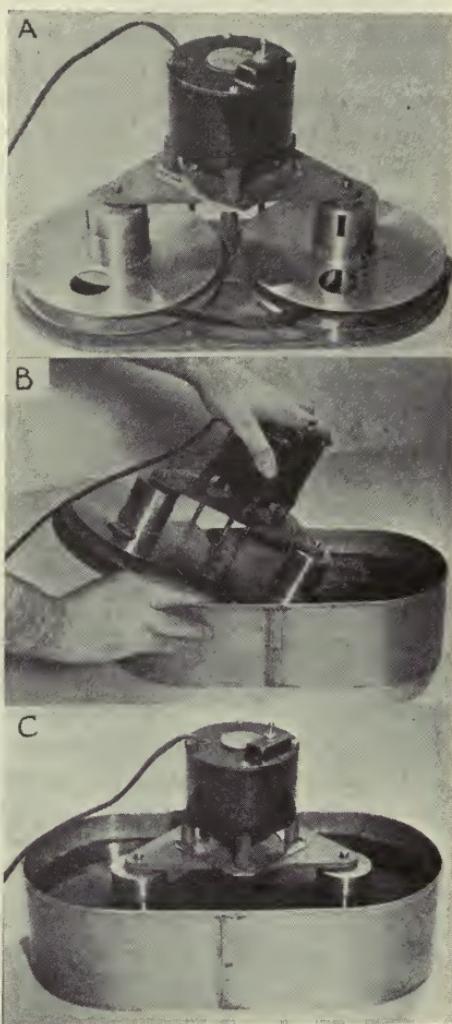


FIG. 11. Smith 16- and 35-mm film developing outfit showing method of winding dry film into prehardener solution.

thickness that will cause uneven contact of successive layers of film as it winds up should be avoided. Splices are best made with cement. A piece of fine sandpaper is taped to the working bench, and the emulsion end of one film and base end of the other are prepared for splicing by rubbing them on the sandpaper until backing and emulsion have been removed. They are then cemented with regular film cement. One-half inch overlap well cemented is adequate.

Negative Processing.—The recommended procedure for 100 ft lengths of film as developed to a negative at 70 F is given in Table 5.

TABLE 5

Solution	Formula	4-In. Hub	Processing Time 2-In. Hub
(1) Prehardener	UH-1	3½ min	4½ min
(2) Negative Dev.	(See below)	7 to 20 min	9 to 25 min
(3) Rinse	Water or SB-1	1½ min	2¼ min
(4) Fix	(a) F-5	15 to 30 min	18 to 40 min
	(b) F-7	5 to 12 min	6 to 16 min
(5)	Running Water	10 to 15 min	11 to 18 min

The time of a complete cycle for 100 ft of film is 2¼ min with the 2-in. hub and 1½ min with the 4-in. hub. If possible, a rapid fixing bath similar to F-7 containing ammonium salts should be used. This will reduce the long fixing times required with this equipment by at least 50 per cent. The prehardener UH-1 is recommended even at 70 F as it holds down development fog, but it can be omitted and a water prewash substituted in its place. The developers and developing times recommended for various film types are given in Table 6. For 200-ft lengths increase the UH-1 prehardener time by 50 per cent over that required for 100 ft.

Positive Films.—Positive film can be processed on the Smith machine to give poor but unsatisfactory results as follows:

100-Ft Run			
Film	Developer	Time in 2-In. Hub	Time in 4-In. Hub
16-Mm 5302 Positive	D-16	10 min	7 min
35-Mm 5302 Positive	D-16	10 min	7 min

Reversal Processing.—Where a reversal image is required the sulfide reversal process is recommended for this equipment. White light may be used after the film is in the bleach. The steps for re-

TABLE 6

Film	Developer	100-Ft Run		200-Ft Run	
		2-In. Hub	4-In. Hub	2-In. Hub	4-In. Hub
16-Mm Universal Sp. Gp. 50	D-76 plus 3 gm per liter Kodalk	15	11	D-76 plus 5 gm per liter Kodalk	19
16- and 35-Mm Negative Sp. Gp. 25	D-76 or DK-50 plus 5 gm per liter Kodalk	17	13	D-76 plus 20 gm per liter Kodalk	17
35-Mm Negative Sp. Gp. 50	(Same as above)	19	15	D-76 plus 20 gm per liter Kodalk	16
16-Mm Universal Sp. Gp. 100	DK-50 plus 5 gm per liter Kodalk or D-76 plus 20 gm per liter Kodalk	22	16	D-76 plus 20 gm per liter Kodalk	12
16- and 35-Mm Negative Sp. Gp. 100	D-76 plus 20 gm per liter Kodalk	19	15	D-76 plus 20 gm per liter Kodalk	30

versal processing of 100-ft lengths of the Universal films at 70 F on the 16- and 35-mm Smith motion picture developing units are listed below.

100-Ft Run

Processing Solutions		Processing Times in Min	
		2-In. Hub	4-In. Hub
(1) Prehardener, Formula <i>UH-1</i>		$4\frac{1}{2}$	$3\frac{1}{2}$
(2) First Developer, Formula <i>RN-1</i>			
16-Mm Universal Sp. Gp. 50		$5\frac{1}{2}$	5
16-Mm Universal Sp. Gp. 100		11	10
(3) Wash		8	7
(4) Bleach, Formula <i>RB-1</i>		8	7
(after 2 min in the bleach turn on white lights)			
(5) Wash		$3\frac{1}{2}$	$3\frac{1}{2}$
(6) Clear, Formula <i>RC-1</i>		$5\frac{1}{2}$	5
(7) Redevelop, Formula <i>RS-1</i>		$5\frac{1}{2}$	5
(8) Wash		9	7
(9) Aerosol Rinse (optional)		$2\frac{1}{4}$	$1\frac{1}{2}$
(10) Squeegee and Dry			

Tropical processing methods on the Smith developer are similar to those given for the tank equipment, using the prehardener, *UH-1*, to which 0.3 gm per liter of 6-nitrobenzimidazole nitrate is added. In general, temperatures above 90 F cause excessive fog on the Smith 16- and 35-mm developer.

FUTURE PROGRAM

Until recently great pressure was exerted to fit these films and processes into existing equipment. This was done and is reflected in the many adaptations and compromises described in previous sections. At the same time the experience gained resulted in new equipment designs which are more suited to these methods and will soon replace the older types.

A new model of the Houston Machine, the *K-3A*, is now being procured instead of the *K-1A* or *K-2A*. The *K-3A* model is slightly longer than the *K-2A*, but of a size that will fit on aircraft carriers and yet have sufficient capacity for the processing needs of most naval air stations. The arrangement of the tanks and partitions is such as to accommodate more easily both the re-exposure and the sulfide reversal processes described, and many improvements over the earlier machines are incorporated.

New-type rack and tank equipment designed particularly for 16-mm field use, with ease of handling and compactness given special consideration, is now being built. Two 55-ft flat rack sections are ingeniously hinged together to hold 110-ft lengths of 16-mm film. The rack is easily loaded and folds to fit processing tanks $3\frac{1}{2} \times 20 \times 20$ in. for $4\frac{1}{2}$ gal of solution. It can be used for re-exposure reversal processes and is suitable for color films.

In conclusion, your speaker wishes to express his appreciation for and acknowledge the great help received from other members of the technical staff at the U. S. Naval Photographic Science Laboratory; they are Lt. Ira B. Current, USNR, Lt. William D. Hedden, USNR, Chief Photographers Mates, Melvin G. Young and Wolcott V. Morgan, and Photographers Mates First Class, John W. McCalley, Justin J. Klem, Al Schick, and William M. Reid. They have labored long and hard to get these methods ready for fleet use.

REFERENCE

¹ MILLER, H. A., CRABTREE, J. I., AND RUSSELL, H. D.: "A Prehardening Bath for High-Temperature Processing," *J. Photo. Soc. Amer.*, 10, 7 (Sept., 1944), p. 397.

APPENDIX

Formulae

The negative developer, Navy Formula N-2 used for low negative contrast on Universal speed group 50 films is a simple elon-sulfite developer.

Negative Developer, Formula N-2

Water.....	800.	cc
Calgon.....	0.5	gm
Elon.....	2.0	gm
Sodium sulfite.....	100.0	gm
Water to.....	1	liter

The formulae for the Navy re-exposure reversal process are listed below:

Prehardener, Formula UH-1

Water.....	800.	cc
Calgon.....	0.5	gm
Sodium bisulfite.....	3.0	gm
Sodium sulfate (anhydrous).....	50.0	gm
Paraformaldehyde.....	4.0	gm
Sodium carbonate (desiccated).....	4.28	gm
6-Nitrobenzimidazole nitrate.....	0.027	gm
Water to make.....	1	liter

First Developer, Formula RN-1

Water.....	800.	cc
Calgon.....	0.5	gm
Elon.....	0.6	gm

Sodium sulfite (anhydrous).....	50.0 gm
Hydroquinone.....	20.0 gm
Potassium bromide.....	8.0 gm
Sodium thiocyanate.....	2.5 gm
Sodium hydroxide.....	20.0 gm
Water to make.....	1 liter

Bleach, Formula RB-1

Water.....	800. cc
Potassium bichromate.....	11.0 gm
Sulfuric acid (concentrated).....	18.0 cc
Water to make.....	1 liter

Clearing Bath, Formula RC-1

Water.....	800. cc
Calgon.....	0.5 gm
Sodium sulfite (anhydrous).....	75.0 gm
Water to make.....	1 liter

Second Developer, Formula RP-1

Water.....	800. cc
Calgon.....	0.5 gm
Elon.....	1.0 gm
Sodium sulfite (anhydrous).....	50.0 gm
Hydroquinone.....	20.0 gm
Potassium bromide.....	5.0 gm
Sodium hydroxide.....	15.0 gm
Water to make.....	1 liter

Fixer R F-2 (F-6)

Water.....	800. cc
Sodium thiosulfate.....	240.0 gm
Sodium sulfite (anhydrous).....	15.0 gm
28 per cent acetic acid.....	48.0 cc
Sodium metaborate.....	15.0 gm
Potassium alum.....	15.0 gm
Water to make.....	1 liter

The formulae of the Navy sulfide reversal process are identical through the clearing bath. The sulfide redeveloper, Formula *RS-1*, replaces the second developer, Formula *RP-1*, and the fixing bath.

Sulfide Redveloper, Formula RS-1

Water.....	800. cc
Sodium metaborate ($\text{Na}_2\text{B}_2\text{O}_4 \cdot 8\text{H}_2\text{O}$).....	20.0 gm
Sodium sulfide ($\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$).....	20.0 gm
Paraformaldehyde.....	2.0 gm
Water to make.....	1 liter

DIRECT-READING FREQUENCY METER*

W. R. STRAUSS**

Summary.—*An instrument capable of indicating audio frequencies of 10 to 50,000 cycles to accuracies limited only by the panel meter or pen-and-ink chart recording meters, regardless of audio-voltage variations, is described herein.*

Designed for rapid, automatic measurements of frequency, a new instrument recently developed by North American Philips Company engineers has sufficient power to operate a strip-chart recorder without an auxiliary amplifier—it does this regardless of audio-voltage variations between the limits of 2 and 200 v. It is most useful where accurate frequency indications are necessary beyond the accuracy of the oscilloscope, and where appreciable loading of high impedance circuits must be avoided.

Sound and radio engineering laboratories are invariably equipped with voltmeters and wattmeters which are calibrated in voltage or decibel ratios. With these instruments frequency response curves are charted automatically or point by point. Often it is desirable to know what frequency is coming through the audio channel without resorting to the oscilloscope or an accurately calibrated signal generator. Most laboratories and repair shops have at least one oscilloscope but very few have accurately calibrated audio-signal generators or means to calibrate them.

Although there are a number of devices that will measure audio frequencies to the accuracy demanded in laboratories, most of these are either cumbersome and difficult to operate, or are limited as to range.

Before the war most audio-measurement work was carried on in the laboratory. However, with production soaring to new peaks and a shortage in technical personnel, there arose a need for a meter that could be operated after only a few minutes of instruction. Such an instrument must maintain calibration for long periods and must

* Presented Apr. 17, 1944, at the Technical Conference in New York.

** Project Engineer, North American Philips Co., Inc., Dobbs Ferry, N. Y.

have a linear frequency-calibrated dial. There must be some means for recording audio frequency on a chart, and checking calibration must be simple so as not to require the services of a technician after necessary tube replacements. In other words, war industries that used audio frequencies in measurement work needed a complicated instrument. Nevertheless, it had to be as easy to operate as a radio set.

The first requisite was a circuit that would respond to a wide range of frequencies and which would maintain constant voltage output throughout a wide range of input voltages. It must handle input

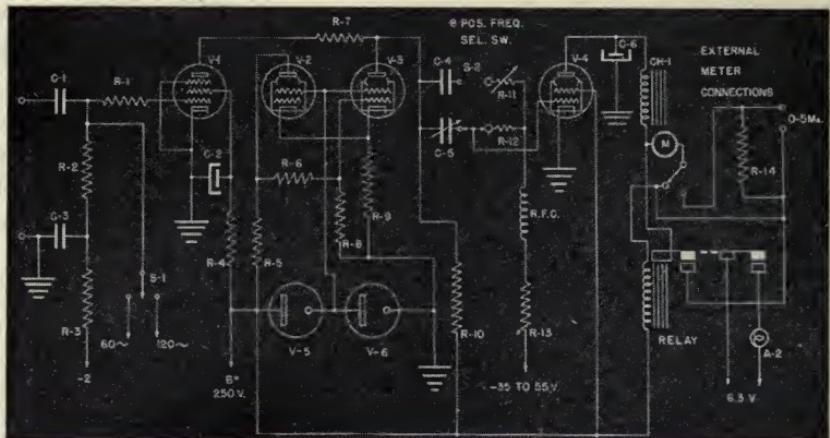


FIG. 1. Input circuit of Philips direct-reading frequency meter. The circuit is similar to that used in television and FM receivers.

potentials from 2 to 200 v, without appreciably loading the audio source under measurement.

The input circuit, shown in Fig. 1, is frequently used in television and FM receivers. It is identified as a limiter in the radio industry and as a plate-saturation circuit by physicists working with electron-counting equipment. The only difference between this circuit and a straight resistance-coupled amplifier lies in resistor $R-1$. The resistance value is not critical, but its purpose is to bias the control grid on the peaks of a cycle. In clipping the peaks of a cycle, the output shows a square wave with steep fronts. The square wave results regardless of whether input frequency is a pure sine wave or one with distortions and irregularities. In case of a badly

distorted wave, the grid circuit will favor the predominant frequency over the lesser peaks by a ratio of about 3 to 1.

Plate output voltage of Fig. 1 is held constant by a "floating" screen grid. Since plate current changes are a function of screen voltage, increase of audio input voltage results in a decrease of screen voltage. This, in turn, is affected by the bias developed across $R-1$. Screen voltages reduce proportionately with increase of grid bias developed across $R-1$. Stabilization of screen resistor $R-4$ to ground, or $B-$ with a bleeder resistor, would limit the range of constant output to a narrow band of frequencies. $C-2$ is an electrolytic condenser which serves as a audio by-pass to prevent any part of the original wave shape from entering the plate circuit. Its value is not critical, but the $R-C$ time constant of $R-1$ and $C-2$ is sufficient to delay any small part of the original wave from coinciding with the square wave, thus avoiding valleys and discharge peaks.

Any remote cutoff pentode may be used at $V-1$, but a type 6AG7 was found to be best from the standpoint of high transconductance and high screen-grid wattage dissipation. With zero signal input the "floating" screen-grid voltage will rise to about 175 v, which is much higher than most screen-grid tubes can tolerate. A 6SK7 is interchangeable with the 6AG7 but requires about $2\frac{1}{2}$ times more voltage input. With a type 6AG7 at $V-1$, the input sensitivity is slightly less than one volt, for almost all frequency ranges. Input impedance is greater than 100,000 ohms for most frequencies but not higher than the value of $R-2$, which is 220,000 ohms. When measuring high-gain tube circuits, this high-input impedance makes possible high audio-frequency measurement with very slight attenuation.

The multivibrator circuit, $V-2$, $V-3$, is directly connected to the plate of $V-1$, and is at rest by virtue of bias-resistor $R-9$. The value of $R-9$ is selected to permit the multivibrator circuit to operate at the instant a square wave voltage is present at the plate of $V-1$. Since $V-1$, $V-2$ tube circuits are not tuned and do not have $R-C$ combinations, the multivibrator circuit has no resonant characteristics—thus its function is to amplify the output of $V-1$ without alteration. The screen-grid and plate-circuit voltages are held constant by the gas-discharge tubes $V-5$ and $V-6$. The frequency response indication, in this application, is not linear because screen voltage increases with frequency. Amplification gain of screen-grid tubes is a function of screen voltage—hence the need for a voltage regulator.

Amplified square waves are then fed into an appropriately chosen $R-C$ ($C-5$, $R-12$, etc.) integrating network. The $R-C$ values determine the amplitude of the pulse that is to appear on the grid of $V-4$. Capacitors $C-4$ (and others in the frequency selector circuit) are either air-type trimmers or silver-mica condensers having negative coefficients to minimize calibration drift caused by heat within the instrument. Operation of the $V-4$ tube circuit is similar to class C audio amplification. Grid bias is adjusted to zero plate current with no signal input. This class of operation functions as a linear amplifier in which plate current changes are directly propor-



FIG. 2. Cabinet installation of Philips direct-reading frequency meter. It can be removed from the cabinet and installed on racks easily.

tional to grid voltages. The grid-bias adjustment is located on the front panel to facilitate control at the time tubes are replaced and when calibration is again necessary.

External and panel meters are protected from burn-out by a relay in the plate circuit of $V-4$. It comes into play when frequencies beyond the selector switch range are applied to the instrument. Currents of 100 ma can be applied for an instant on the 5-ma meter. The relay shorts the meter only when currents exceed 10 ma and releases at about 4 ma. The meter circuit is arranged to permit reading the panel and external meters simultaneously. A panel switch disconnects the external meter if it is not needed, without disconnecting wires. Accurate frequency indication on the external

meter is only limited by the meter itself. If a recorder is used, overshooting and undershooting of the pen (determined by chart paper travel) must be taken into consideration. If the frequency meter is accurately calibrated and stabilized, the inherent circuit error will be less than 0.5 per cent over the entire range of 10 to 50,000 cycles.

To dampen pointer oscillation and resonance at low frequencies, a long-time constant R - C network (*C-6, CH-1*) has been incorporated into the plate circuit of *V-4*. Without the R - C network, some re-

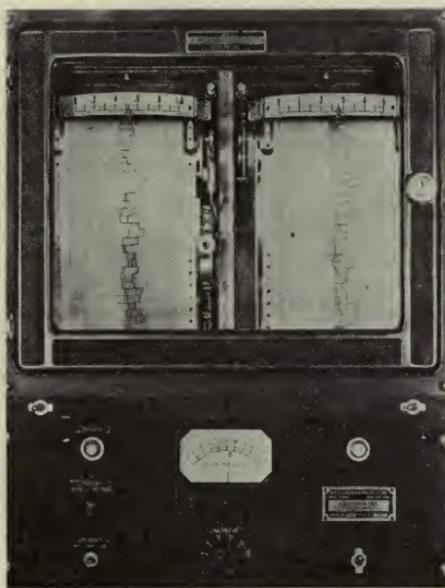


FIG. 3. Philips direct-reading frequency meter installed on rack and driving a 5-ma recorder without an auxiliary amplifier.

corder pens have been found to resonate badly at 100 to 130 cycles with the selector switch (*S-2*) set on 100- or 500-cycle positions. Any external meter having a 5-ma movement and a coil resistance not exceeding 1000 ohms, may be used without recalibration. *R-14* is an external-meter damping resistor of 10,000 ohms. It was chosen as an optimum value and will accommodate most recorders without affecting calibration. Generally speaking, recorders have a coil resistance of 100 to 400 ohms.

Calibration frequency for the instrument is taken from the power supply line—60 cycles at 6.3 v is obtained from the filament leg of

the transformer and 120 cycles at 2.5 v comes from the *B* leg of the full wave power rectifier, through a 47-ohm resistor. The calibration switch is normally open (center position) as shown in Fig. 1. Selector switch *S-2* is placed on the 100- or 500-cycle range when making a calibration check.

Fig. 2 shows a cabinet installation. Removed from its cabinet, the instrument can be easily adapted to rack mounting, as shown in Fig. 3—here the frequency meter is shown operating with a recorder.

The frequency meter has proved its usefulness in the following fields:

- (1) It measures audio-frequency differences in quartz crystal manufacturing.
- (2) It measures temperature-coefficient drift on transmitters and receivers operating under test temperatures of from -40 to 200 F.
- (3) It measures frequency produced by transient voltages in audio circuits.
- (4) It checks phonograph-motor speed with frequency records.
- (5) It is valuable in some phases of Radar application.
- (6) It determines pulse frequencies.
- (7) It functions for gamma, X-ray, and electron counting.
- (8) It serves for "wow" testing of phonograph turntables.
- (9) It determines a-c line frequencies for power and audio-transformer design.
- (10) It is valuable for ultrasonic work and other applications that have to do with frequencies between 10 and 50,000 cycles.

No doubt, the instrument will soon find application in the sound motion picture industry. Here it should prove valuable for testing sound tracks and motor speeds; it can also be useful in flicker checking.

STATEMENT OF THE SMPE IN OPPOSITION TO THE BRIEF OF THE COLUMBIA BROADCASTING SYSTEM AS IT RELATES TO THEATER TELEVISION*

Ed. Note.—The Society of Motion Picture Engineers, at the original hearing before the Federal Communications Commission (Docket No. 6651) in October 1944, requested allocation of frequencies for a national theater television service in behalf of the engineers of the motion picture industry. In view of this request the FCC granted allocation of frequencies for theater television on an experimental basis as set forth in their Proposed Allocation Report. The statement of the SMPE and excerpts from the FCC report were published in the February 1945 Journal, pp. 105–137.

As the report by the FCC was a proposal only, a rehearing was proposed by the FCC to give all parties an opportunity to present additional testimony. The SMPE was of the opinion that the frequencies allotted for experimental theater television were adequate and accordingly advised the Commission that it did not intend to submit further testimony at the rehearing. (See Appendix A, p. 270 of this issue.)

Prior to the date of the rehearing, the Columbia Broadcasting System, Inc., filed a brief with the FCC in opposition to some of the allocations proposed by the Commission. CBS requested the FCC not to allocate any frequencies for a theater television service as such allocation was contrary to the FCC rules and regulations, and further, such allocation would favor only a few and might establish monopolistic franchises. Excerpts from the CBS brief are given on pp. 272–274 of this issue.

In view of the opposition by CBS, the Society, through its representative, Paul J. Larsen, presented the following statement before the FCC at the rehearing on Mar. 2, 1945.

Mr. Chairman, Members of the Commission:

My name is Paul J. Larsen. I am a radio engineer associated with The Johns Hopkins University, Applied Physics Laboratory in war activities for the Bureau of Ordnance, U. S. Navy Department. I appear before the Commission today as the representative of the Society of Motion Picture Engineers to present their opposition to the Brief of the Columbia Broadcasting System, Inc., as it relates to Theater Television. I appeared before your Commission during the allocation hearing on October 27, 1944 (Tr., pp. 3711–3755) at which time allocation of frequencies in the Radio Spectrum for Theater

* Presented before the Federal Communications Commission (Docket No. 6651, Exhibit No. 598) by Paul J. Larsen, SMPE Representative, on Mar. 2, 1945.

Television was requested for the Motion Picture Industry, as more fully set forth in the statement, FCC Exhibit No. 431.

The Society of Motion Picture Engineers advised the Commission that they did not intend to submit additional testimony at this hearing unless the proposed experimental allocation of frequencies for Theater Television were attacked by any other party appearing at the hearing. (See Appendix A, page 270 of this issue, letter dated Feb. 23, 1945.)

The Columbia Broadcasting System, Inc., in their Brief dated February 20, 1945, "submits that no frequencies should be assigned to Theater Television" (Brief, pp. 35, 36). This request is based upon pertinent principles outlined in the Brief, applied to their submission "that no frequencies should be assigned to subscription radio." The principles outlined against subscription radio, Columbia Broadcasting System, Inc., states "apply with at least equal force to the requested use of frequencies for Theater Television."

The purpose or intent behind this request of the Columbia Broadcasting System, Inc., in view of their previous implied support, is not stated. In view of this request by the Columbia Broadcasting System, Inc., that "no frequencies should be assigned to Theater Television," the Society of Motion Picture Engineers respectfully requests to submit the following in opposition thereto:

The principles applied by the Columbia Broadcasting System, Inc., to Theater Television are outlined on pages 35 to 40 of their Brief. We have applied these principles to Theater Television and fail, by the broadest interpretation of the principles, to apply them to the request "that no frequencies should be assigned to Theater Television." We submit herewith our comments in respect to each of the principles set forth by the Columbia Broadcasting System, Inc.

1. THEATER TELEVISION IS NOT BROADCASTING:

The Society of Motion Picture Engineers has at no time contended that Theater Television is broadcasting. The testimony submitted in behalf of Theater Television by Paul J. Larsen (Tr., pp. 3711-3755) and FCC Exhibit No. 431, specifically requested the Commission to classify Theater Television as a communication of a private nature to differentiate it from Television Broadcasting. Admittedly, Theater Television is in direct conflict with the basic concept of broadcasting. It is contended and supported in FCC Exhibit No.

431 that the public will benefit from the television service rendered to the theaters. The Motion Picture Industry is capable, based upon its past public record of presenting visual and aural presentations in theaters, to carry out its obligation to present through this companion medium, television, equal presentations.

2. ASSIGNMENT OF CHANNELS TO THEATER TELEVISION WOULD VIOLATE COMMISSION'S GENERAL PRINCIPLES OF ALLOCATION:

(a) **Theater Television Could Utilize Wire Lines.**—The attempt by the Columbia Broadcasting System, Inc., in their Brief to apply the discussion of "General Principles" outlined in the Commission's report (R. 18) "...with the severe shortage of frequencies, it would not be in the public interest to assign a portion of the spectrum to a service which could utilize wire lines instead. . ." to Theater Television seems inapplicable to the frequency spectrum here involved and further unfounded in view of the testimony submitted in relation to television in general. The proposed operation of Theater Television cannot be carried on by wire lines as is Muzak today. The wire lines utilized for Muzak are high-quality program telephone lines having a band width limit of approximately 7500 cycles. For television and Theater Television, utilization of coaxial cables will be experimented with. However, based upon present technical knowledge and upon the testimony submitted by the American Telephone and Telegraph Company at the hearing, coaxial cables are not available with sufficient band width, of the order of 6 to 8 megacycles, required for a Theater Television service. The Society of Motion Picture Engineers requested allocation of frequencies for radio linkage systems to insure adequate band width for the service contemplated.

(b) **Only a Limited Number of People Would Benefit.**—Here again the Columbia Broadcasting System, Inc., attempts to interpret the Commission's "General Principles" in the report by selecting phrases having no bearing upon the service of Theater Television.

The Commission certainly must have taken into consideration the general principles quoted by the Columbia Broadcasting System, Inc., when the Commission allocated on an experimental basis the frequencies for Theater Television.

Columbia Broadcasting System, Inc., in respect to the above principles, quoted the following paragraph from the report: "With the shortage of frequencies available, the Commission did not believe

that it would be in the public interest to assign frequencies to a new service unless it could be shown that there would be public acceptability and use of the service." The Commission, having made this statement in their "General Principles" and then having assigned frequencies on an experimental basis for Theater Television, must have believed that Theater Television would have public acceptability.

Does the Columbia Broadcasting System, Inc., by quoting this passage from the Commission's "General Principles" infer that Theater Television, as a new service, would not have public acceptability? The Society of Motion Picture Engineers contends that all of the evidence submitted in their testimony and in FCC Exhibit No. 431 shows conclusively that Theater Television would have public acceptability and the Motion Picture Industry intends to establish this service. The Society of Motion Picture Engineers, in behalf of the engineers of the Motion Picture Industry, submits that it doubts whether Television Broadcasting will have a greater public acceptability than Theater Television or make greater use of the service in the public interest.

The Columbia Broadcasting System, Inc., also states "the proposed service would be of benefit to only a small portion of the public—the upper income levels." This is a new thought introduced into the Motion Picture Industry. We question the sincerity of this statement as it is so wholly unfounded. It is doubtful if anyone can question that the Motion Picture Industry has at any time limited its service to a select few. The weekly attendance in Motion Picture Theaters exceeds 85,000,000 persons and the Industry is certain that this does not represent the "upper income levels."

The Society of Motion Picture Engineers fails to find any logic in the arguments presented by the Columbia Broadcasting System, Inc., in respect to these principles. Their purpose in submitting these statements against Theater Television, as aforesaid, has not been stated. We can only interpret these statements as being a fear by the Columbia Broadcasting System, Inc., of competition by Theater Television, even though not expressly stated. The Society of Motion Picture Engineers, in behalf of the engineers of the Motion Picture Industry, wishes to submit to the Commission that it does not fear competition of Television Broadcasting but invites it. It is hoped that the Television Broadcasting Industry has the same attitude.

3. THEATER TELEVISION WOULD VIOLATE SECTION 3.230 OF COMMISSION'S RULES AND REGULATIONS:

The allegations set forth by Columbia Broadcasting System, Inc., under this principle, do not apply to Theater Television. Section 3.230 of the Commission's rules and regulations applies to broadcast stations. Theater Television is not a broadcast service and therefore these rules and regulations do not apply.

4. THE PROPOSED ALLOCATION FOR COMMERCIAL FM BROADCASTING IS LESS THAN ADEQUATE:

The Society of Motion Picture Engineers fails to find any principles under this heading that apply to Theater Television, as the FM Broadcasting is in a part of the radio spectrum not considered for Theater Television.

The request for frequency allocations for Theater Television by the Society of Motion Picture Engineers was based upon obtaining adequate frequency allocations to permit a competitive National Theater Television Service. For the immediate post-war period it was recommended that frequency allocations be made to permit competition by 15 producing or exhibiting agencies in an area such as New York City. This is certainly far remote from the contention implied by the Columbia Broadcasting System, Inc., that Theater Television may set up a monopolistic franchise.

The Society of Motion Picture Engineers is of the opinion that the frequencies requested for Theater Television will serve a very large portion of the public without distinction as to income level. The Motion Picture Industry has the organization to produce, and the technical "know how" of the type of visual entertainment required for public consumption. The Industry has 50 years of background experience and has acquired the "know how" of public desires in the visual entertainment field. During the initial commercialization of television, whether broadcasting or theater, the public will view the presentations due to their "novelty," that is, the novelty of being able to view a visual presentation transmitted through the medium of radio. This novelty period will soon wear off and it will then be necessary to present proper program material having human interest and entertainment value to insure continued commercial success. The Motion Picture Industry has gone through this period during its history in presenting visual presentations in theaters throughout this country and the world, and it is believed that they have the or-

ganization, the background, the experience, the technique, and the "know how" to insure the public that the visual presentations which they will present through Television will be comparable to the high standard in artistry and technical perfection to which the theatrical public is accustomed.

5. THEATER TELEVISION SHOULD BE ASSIGNED FREQUENCIES ALLOCATED TO POINT-TO-POINT SERVICES, IF AT ALL:

The Society of Motion Picture Engineers, in their original request for allocation of frequencies for Theater Television, recommended that Theater Television should be classified as a communications service of a private nature, to differentiate it from broadcasting.

It is believed that the Columbia Broadcasting System, Inc., has erroneously interpreted the Commission's assignment of frequencies for experimentation of Theater Television, by their statement "...if at all," and "...if frequencies are, at a future date, to be assigned...." The Commission, in their report, although not allocating or assigning specific frequencies at this time for Theater Television, did assign frequency bands in which experimentation of Theater Television would be authorized, namely, the following bands:

- 480-920 megacycles (On the basis that the use of frequencies within this band will be discontinued when needed for the broadcast service.)
- 1900-2300 megacycles
- 3900-4550 megacycles
- 5750-7050 megacycles
- 10,500-13,000 megacycles
- 16,000-18,000 megacycles
- 26,000-30,000 megacycles

The Society of Motion Picture Engineers submits that the request of the Columbia Broadcasting System, Inc., in their Brief, be disregarded by the Commission as no logical reason has been expounded why Theater Television should not have a permanent place in the allocation picture.

SUMMARY

- (1) The Society of Motion Picture Engineers respectfully requests the Commission to reaffirm the experimental allocation of frequencies for the service of Theater Television in the following bands of frequencies:

1900-2300 megacycles
3900-4550 megacycles
5750-7050 megacycles
10,500-13,000 megacycles
16,000-18,000 megacycles
26,000-30,000 megacycles

(2) The Society of Motion Picture Engineers respectfully requests that the Commission reaffirm its allocation of frequencies between 480 and 920 megacycles for television, but modify their allocation of these frequencies to a "parity of opportunity basis" allocation between Television Broadcasting and Theater Television, as both of these services have an equal interest and an equal responsibility to the public in the visual and aural entertainment field. Such an allocation on a "parity of opportunity basis" would foster competition, a sound democratic policy;

(3) That the frequencies so allocated for Theater Television on a "parity of opportunity basis" with Television Broadcasting between 480 and 920 megacycles be made on the basis that if, as a result of experimentation of Theater Television on frequencies within this band compared to experimentation of Theater Television in the higher frequency bands, the results are such that Theater Television can make the best use of this allocated band, all factors concerned, that the allocation then be made permanent to Theater Television;

(4) That the opposition by the Columbia Broadcasting System, Inc., to allocation of any frequencies to Theater Television, be denied by the Commission as the grounds and allegations set forth by Columbia Broadcasting System, Inc., are unfounded and not applicable to Theater Television, and also on the basis that competition between Television Broadcasting and Theater Television is desirable technically and is to the best interest of the public.

APPENDAGE A

SOCIETY OF MOTION PICTURE ENGINEERS

February 23, 1945

Mr. T. J. Slowie
Federal Communications Commission
Pennsylvania Ave., between 12th & 13th N.W.
Washington, D. C.

Subject: Oral Hearing, FCC Docket No. 6651
Scheduled for Feb. 28, 1945

Dear Mr. Slowie:

The Society of Motion Picture Engineers, in behalf of the engineers of the Motion Picture Industry, has reviewed the proposed frequency allocations as reported in the FCC report dated January 15, 1945, particularly as they apply to Theater Television Services, Section 17, IV.

In our judgment we believe that the Commission, considering the magnitude of the problem confronting them, has made a fair and reasonable allocation of frequencies after reconciling the numerous requests for space in the available spectrum.

In respect to the allocations of frequencies for Theater Television it is noted that experimentation with intra- and inter-city relay of theater television programs may be authorized in the following bands:

1900-2300 mcs
3900-4550 mcs
5750-7050 mcs
10,000-13,000 mcs
16,000-18,000 mcs
26,000-30,000 mcs

In addition, the Commission also advised that they would consider applications for experimental authorization involving intra-city transmissions, including studio to transmitter, remote pickup, and intra-city multiple address stations, on frequencies between 480 and 920 megacycles, allocated to television broadcasting, on the basis that the use of these frequencies will be discontinued when needed for the broadcast service.

From the above, it will be noted that a difference in interpretation as to the scope of the services can be inferred, as no provision for experimentation with intra-city multiple address stations is made in the higher frequencies, 1900 to 30,000 megacycles. On the basis of this interpretation the allocations seem inadequate for a National Theater Television Service. The allocation provided on the basis of the Commission's decision restricts the frequency spectrum from 480 to 920 megacycles in which intra-city multiple address stations are permitted, for temporary use only until these frequencies are needed for broadcast service.

The Society of Motion Picture Engineers feels that it was the intention of the Commission in their report to permit experimentation of the different services required for Theater Television in the higher frequencies, on the same basis as in the 480 to 920 megacycle band, until this band is needed for the broadcast serv-

ice. It is hoped that this interpretation is correct and that in the final report this point will be clarified.

At the original hearing the Society of Motion Picture Engineers requested frequencies for the new Theater Television Service between 600 and 1000 megacycles. The specific request for frequencies being a band of 160 megacycles from 600 to 760 megacycles, and a band of 140 megacycles from 860 to 1000 megacycles. The request for these frequencies was made to permit the Motion Picture Industry to establish a Theater Television Service in the immediate post-war period with equipment now known to be available. Design and development of equipment for use in the higher frequencies above 1900 megacycles, and prolonged field experimentation of this equipment, will be necessary before adoption for a Theater Television Service.

The request for frequencies below 1000 megacycles, totaling a band width of 300 megacycles for Theater Television, was also made so as to be on a "parity of opportunity basis" with television broadcasting. This "parity of opportunity basis" was set forth in FCC Exhibit No. 431 and in the statement of Paul J. Larsen before the Commission at the hearing. It is noted that the Commission has made no reference to this "parity of opportunity basis" in their report.

The Society of Motion Picture Engineers is still of the opinion that the Motion Picture Industry is entitled to this "parity of opportunity basis" with television broadcasting, and therefore respectfully requests the Commission to consider specific allocation of frequencies on a "parity of opportunity basis" with television broadcasting in the 480 to 920 megacycle band now proposed for allocation to television broadcasting.

The Society of Motion Picture Engineers submits that if, as a result of the experimental use of the frequencies between 480 and 30,000 megacycles, it is found that theater television can make the best use of a portion of the band between 480 and 920 megacycles, all factors considered, that the Commission give consideration to the assignment of such a portion for commercial Theater Television.

It is noted in the report that the Commission will, after experimentation, and upon adequate showing of the requirements, allocate specific bands of frequencies to the new services, including Theater Television. In view of this fact, and that the Commission will consider the requests herein in their final report, the Society of Motion Picture Engineers does not plan to present additional testimony at the hearing on February 28th. The Society of Motion Picture Engineers, however, wishes to reserve the right to be heard in event allocations now proposed for experimental Theater Television are affected by additional testimony by other interests.

The Society of Motion Picture Engineers wishes at this time to pledge, on behalf of the engineers of the Motion Picture Industry, their full cooperation to the Federal Communications Commission. We also wish to compliment the Commission and its engineers upon their sound forward-looking policy in the allocation of frequencies for the many radio services.

Very truly yours,

PAUL J. LARSEN
1401 Sheridan St., N.W.
Washington, D. C.

EXCERPTS FROM THE BRIEF OF THE COLUMBIA BROADCASTING SYSTEM RELATING TO THEATER TELEVISION***III. REQUESTS FOR BROADCASTING CHANNELS FOR FM AND TELEVISION POINT-TO-POINT COMMUNICATIONS****Statement**

Proposals were made at the hearing that frequencies within the proposed FM broadcast band be assigned to a new service, called subscription radio, designed to be received only by those set owners who would pay a fee to the transmitting station equal to 5¢ per day (approximately \$18 per year). Non-subscribers would be prevented from receiving this service by a super-imposed tone, or "pig-squeal," which could be filtered out only by a patented device owned by the originators of the service and installed only in sets of persons paying the 5¢ a day royalty.

A representative of the Society of Motion Picture Engineers proposed the assignment of frequencies within the proposed high-definition television broadcast band to be utilized by producers and distributors of motion pictures for transmitting their service to theaters and there to be viewed by the public upon the payment of regular admission charges.

The Commission refused to assign frequencies at this time for subscription radio but stated:

"If this service proves feasible and the Commission decides to license stations of this type, applicants will be permitted to apply for channels in the regular FM commercial band or in such other band or bands as the Commission may later designate" (R. 74).

The Commission likewise refused to assign frequencies for theater television but stated that it would give consideration to applications for experimental authorization in this field on frequencies between 480 and 920 mc allocated to broadcasting on the basis that the use of these frequencies will be discontinued when needed for the broadcast service (R. 189).

Columbia submits that no frequencies should be assigned to subscription radio or theater television.**

1. Subscription Radio Is Not Broadcasting.

The Communications Act of 1934 defines broadcasting thus:

"'Broadcasting' means the dissemination of radio communication intended to be received by the public, directly or by the intermediary of relay stations." Sec. 3(o).

The proposal for subscription radio is in direct conflict with the basic concept of broadcasting—that is, that everyone may listen freely to all programs. Under the proposal the public would be required to pay a fee to private individuals for the privilege of listening to a broadcast made over frequencies which are licensed in the public interest.

* Pp. 35-40, inclusive.

** The pertinent principles will be discussed as they apply to the proposal for subscription radio. These apply with at least equal force to the requested use of frequencies for theater television.

2. Assignment of Channels to Subscription Radio Would Violate Commission's General Principles of Allocation.

(a) *Subscription Radio Could Utilize Wire Lines*

In its discussion of "General Principles" followed by the Commission in making proposed allocations, the Commission stated (R. 18) ". . . with the severe shortage of frequencies, it would not be in the public interest to assign a portion of the spectrum to a service which could utilize wire lines instead. . . ." The proposed operation is one that can be carried on by wire lines as is the Muzak we know today, and as is the European counterpart of the proposed service. The only objection to the use of wire lines is that such a method of operation would increase the cost, but, as will be pointed out later, the proposed service will be available at best only to those located in large metropolitan areas and only to the wealthier among them.

(b) *Only a Limited Number of People Would Benefit*

In its discussion of "General Principles" followed by the Commission in making proposed allocations, the Commission stated (R. 18 and 19) that, ". . . the Commission was concerned with the total number of people who would probably receive benefits from the particular service. Where other factors were equal, the Commission attempted to meet the requests of those services which proposed to render benefits to large groups of the population rather than of those services which aid relatively small groups. . . . With the shortage of frequencies available, the Commission did not believe that it would be in the public interest to assign frequencies to a new service unless it could be shown that there would be public acceptability and use of the service."

The proposed service would be of benefit to only a small portion of the public—the upper income levels. Mr. Hurdman, Muzak's Chief Engineer, testified as follows: "As a matter of fact, I think if you get the area too large, you would not be able to service it. I think it is essentially a small area coverage on account of the difficulties of collection and servicing." (Tr. 1396.) Mr. Weiner testified, "I would not undertake to dignify any figure I give now as an estimate, but I would say we would make an effort at getting somewhere between, say, 10% and 40% of the radio set owners." (Tr. 1408.) He further testified that his clients now contemplate operation in only three major markets (Tr. 1385).

3. Subscription Radio Would Violate Section 3.230 of Commission's Rules and Regulations.

In view of the fact that the present proposal contemplates three simultaneous services from three separate stations, subscription radio would violate Section 3.230 (a) of the Commission's Rules and Regulations which provides

"No person (including all persons under common control) shall, directly or indirectly, own, operate, or control more than one high frequency broadcast station that would serve substantially the same service area as another high frequency broadcast station owned, operated, or controlled by such person."

To make an exception to the rule for subscription radio would be manifestly unfair to FM broadcasters and to the licensees of the standard stations who have

been compelled to dispose of their stations under Section 3.35 which is a parallel rule applicable to standard broadcast stations.

Subscription radio, as proposed, also would violate Section 3.230 (b) of the Commission's Rules and Regulations which provides

"No person (including all persons under common control) shall, directly or indirectly, own, operate, or control more than one high frequency broadcast station, except upon the showing: (1) that such ownership, operation, or control would foster competition among high frequency broadcast stations, or provide a high frequency broadcasting service distinct and separate from existing services, and (2) that such ownership, operation, or control would not result in the concentration of control of high frequency broadcasting facilities in a manner inconsistent with public interest, convenience, or necessity; . . ."

Again, any exception made to such rule on behalf of subscription radio would be discriminatory against FM broadcasters.

4. The Proposed Allocation for Commercial FM Broadcasting Is Less Than Adequate.

As pointed out elsewhere in this brief, the proposed allocation of channels to FM broadcasting is considered to be less than adequate. Yet, proponents of subscription radio propose that a single person be the licensee of three FM stations in any given area in which subscription radio would operate.

Even if the proposed three channel allocation were not to be made to subscription radio, there will be insufficient space in the proposed commercial FM band to take care of even the present FM applicants from that area. As pointed out above, the testimony of Messrs. Weiner and Hurdman indicates that subscription radio would probably be workable only in the large metropolitan areas where wealth is concentrated and which are feasible from the standpoint of servicing. The allocation of a portion of the band to subscription radio for use in the large metropolitan areas would necessarily limit or prevent the possibility of such expansion in the very areas that will be most cramped for space.

This is the situation which would exist if only one organization were licensed to carry on the business of subscription radio in any one area. If, however, allocations were to be made so as to permit competition among subscription radio licensees—and it cannot be supposed that the Commission would countenance a monopolistic franchise in this field—the situation described would become so magnified as to force broadcasters from the FM band.

It seems thoroughly inappropriate, therefore, to attempt to deny the use of needed frequencies to a proven service available without charge to the entire public in favor of something which will serve only a small part of the public who are able and willing to pay the special fees required.

5. Subscription Radio Should Be Assigned Frequencies Allocated to Point-to-Point Services, If At All.

It is submitted that if frequencies are, at a future date, to be assigned to subscription radio that those frequencies should be in the point-to-point band, inasmuch as the proposed service is a multiple address radio service rather than a broadcasting service.

ANALYSIS OF GENEVA MECHANISMS*

WILLIAM A. WILLIS**

In the mechanical design of practically all types of instruments, it is necessary for certain parts to operate intermittently relative to a continuously moving part. A popular and simple means of obtaining this movement is by the use of the Geneva mechanism.

The Geneva mechanism is so named because its operation is based upon the principle of the stop in Geneva watches which prevents overwinding the mainspring by checking the winding stem after a predetermined number of turns. Now universally used in motion picture projectors for synchronizing the movement of the film with that of the shutter, the Geneva mechanism also has various applications in indexing devices for machine tools. In the design of communications and navigational equipment, it is useful for electrical tuning and band change drives (see Fig. 1), in dial indicating mechanisms, in coil tuning and switch positioning, and in numerous other applications.

Commonly Used Type.—One type of Geneva mechanism in general use, shown in Fig. 2, operates as follows. The driven disk B has 4 radial slots spaced 90 degrees apart, and between these are 4 concave surfaces C of circular shape to match locking ring D on the face of driver A. The driver carries a pin or roller P, which during each revolution engages one of the radial slots S of driven disk B and thereby rotates it one-quarter of a revolution. The ring D is cut away to provide clearance for the passage of the slotted arm, after which passage it is held stationary by the interlocking of surfaces C and D. The driver A then rotates the remaining three-quarters of its revolution.

In this type of mechanism, particularly if operated at high speed, it is desirable to design the driver and driven disk so that the pin P will enter and leave the slot S tangent to the circular path of the pin,

* Reprinted from *Bendix Radio Engineer*, 1, 3 (Jan., 1945), p. 8.

** Chief Mechanical Engineer, Receiver Engineering, Bendix Radio Division of Bendix Aviation Corporation, Baltimore, Md.

making the angle Θ 90 degrees. The angle B equals $180/N$, where N is the number of slots in the driven disk.

The least number of slots with which it is possible to operate the driven disk is three; and if the width of the slot and the radius of the circular path of the driving pin may be considered infinitely small, the greatest number of slots possible for operation may be considered as infinite. Thus the theoretical limit for the number of slots lies between three and infinity.

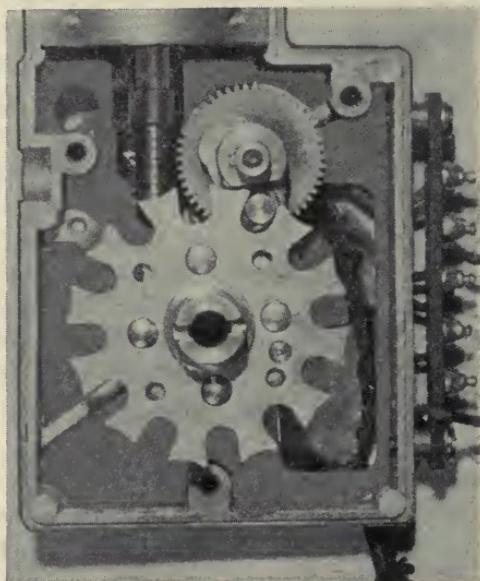


FIG. 1. Geneva mechanism in band-switch motor.

Inspection of Fig. 2 shows that since the length of the driver arm A is constant throughout its cycle of operation and rotates at a constant velocity, the effective arm of the driven disk B varies continuously and decreases to a minimum length when the pin is on the line of centers. At this point the driven disk is rotating at its maximum velocity.

In making a kinematic analysis of this Geneva mechanism, several analytical or graphic methods may be used; and although analytical methods are inherently more accurate, graphic methods carefully drawn to a large scale will produce results with less than 2 per cent error. This is sufficiently accurate for the majority of applications.

If it is desirable to find the kinematic properties for only one instantaneous position of the mechanism, the direct vector solution is the logical method to use, but usually the properties must be determined for a sufficient number of positions to show their variations for a complete cycle of operation. In such cases other quicker and less cumbersome methods are used.

Velocity Analysis.—Kinematically, the Geneva mechanism shown in Fig. 2 may be represented as 2 rotatable links in direct contact as shown in Figs. 3, 4, and 6. As in most all velocity problems, a little ingenuity must be exercised in deciding on the best method of attack. Fig. 3 shows the direct vector solution for finding the linear velocities for an instantaneous position of the driver link, where

V_A = linear velocity of link A;

V_B = linear velocity of link B;

V_R = linear velocity of point P on link A relative to P on link B.

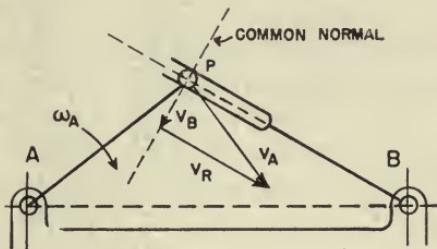


FIG. 3. Kinematic diagram for direct vector velocity solution.

links has a certain velocity, whether it be considered in either one or the other." The permanent centros of links A and B are their axes of rotation FA and FB, and the nonpermanent centro AB may be found as follows.

The links are to remain in contact during motion so the surfaces of contact between pin P and slot S will always have a common tangent T-T and common normal N-N. Since the links A and B must not separate nor crush each other, there can be no relative motion be-

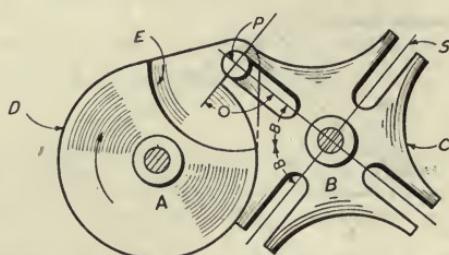


FIG. 2. Typical Geneva mechanism.

Fig. 4 shows the direct-centro method of solution which is recommended for finding the angular-velocity ratio of links A and B for a complete cycle of operation. The angular-velocity ratio of driver link A to driven link B in any phase may be found by making use of the "condition that the common centro of any 2

tween P and S along the direction of the normal N-N. The only motion they can have must be that of sliding in the direction of the common tangent T-T; hence the centro AB must be somewhere along the common normal N-N. And, in accordance with Kennedy's theorem which states that, "any 3 bodies having relative plane motion have but 3 centros which must lie on the same straight line," the centro AB is at the intersection of N-N with the line of centers of links A and B.

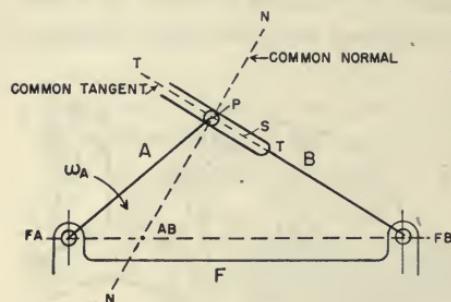
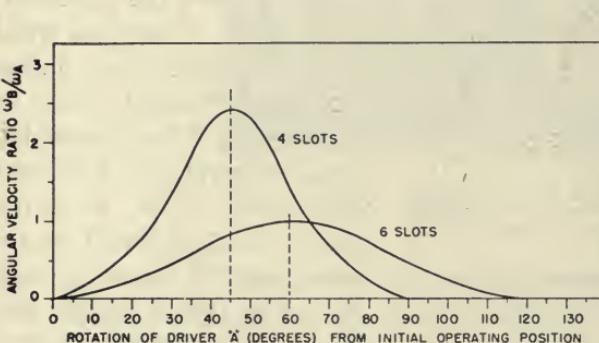


FIG. 4. Diagram for direct-centro velocity solution.

Let:

- ω_A = angular velocity of link A in radians per second;
- ω_B = angular velocity of link B in radians per second;
- ω_{AB} = angular velocity of centro AB in radians per second;
- V_A = linear velocity of point on link A;
- V_B = linear velocity of point on link B;
- V_{AB} = linear velocity of centro AB.



6 SLOT CURVE		4 SLOT CURVE	
ROT	$\frac{\omega_B}{\omega_A}$	ROT	$\frac{\omega_B}{\omega_A}$
0	0	0	0
10	.12	5	10
20	.27	15	40
30	.47	25	96
40	.71	35	1.8
50	.91	45	2.4
60	1.0	55	1.8
70	.91	65	.96
80	.71	75	4.0
90	.47	85	1.0
100	.27	90	0
110	.12	120	0

FIG. 5. Curve for obtaining angular velocity ratio of Geneva mechanisms.

Then, from the known relation between angular and linear velocity of $\omega = V/r$,

$$V_{AB} = \omega_A (FA - AB) \quad (1)$$

considering AB a point in link A;

$$V_{AB} = \omega_B (FB - AB) \quad (2)$$

considering AB a point in link B.

Equating (1) and (2),

$$\frac{\omega_A}{\omega_B} = \frac{(FB - AB)}{(FA - AB)} \quad (3)$$

or the angular velocities of links A and B are inversely proportional to the distance of their common centro AB from their centers of rotation FA and FB.

Using this method of analysis and the velocity ratio for every 5 or 10 degrees movement of driver link A, we obtain the curve shown in Fig. 5. A similar curve for a 6-slot disk is also shown to illustrate how the maximum angular-velocity ratio decreases as the number of slots is increased.

Checking Solutions.—In general, the graphic method described for determining the angular-velocity ratio of the Geneva mechanism is desirable. But a mathematical analysis, though generally producing a complicated equation and often inconvenient to use, has restricted applications, and is recommended for checking graphic solutions, particularly for the maximum point of velocity.

For a direct mathematical analysis, the Geneva mechanism should be represented as shown in Fig. 6.

Let:

R = length of driver link A;

C = length of center distance between links;

β = initial operating position of link A;

α = angular rotation of driver link A from initial operating position;

ω_A = angular velocity of driver link A;

ω_B = angular velocity of driver link B.

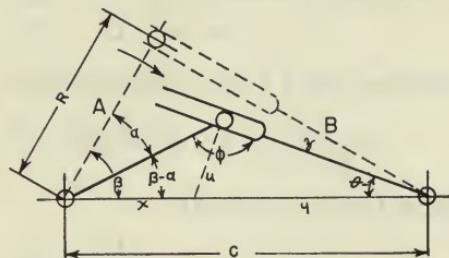


FIG. 6. Diagram for mathematical analysis.

Remember that R and C are constants, and driver link A is rotating at a constant velocity. The angular velocity of link A at any instant is found by differentiating $(\beta - \alpha)$ with respect to time, and that of link B by differentiating Θ with respect to time, thus:

$$\omega_A = \frac{d(\beta - \alpha)}{dt}; \omega_B = \frac{d\theta}{dt}.$$

Therefore, the angular-velocity ratio of link A to B equals:

$$\frac{\omega_B}{\omega_A} = \frac{d\theta/dt}{d(\beta - \alpha)/dt} = \frac{d\theta}{d(\beta - \alpha)}.$$

From law of sines:

$$\frac{\sin(\beta - \alpha)}{z} = \frac{\sin \theta}{R}. \quad (4)$$

Differentiating both sides with respect to $(\beta - \alpha)$:

$$\frac{\cos(\beta - \alpha)}{z} - \frac{\sin(\beta - \alpha)}{z^2} \frac{dz}{d(\beta - \alpha)} = \left(\frac{\cos \theta}{R} \right) \frac{d\theta}{d(\beta - \alpha)}. \quad (5)$$

From law of cosines:

$$z^2 = R^2 + C^2 - 2RC \cos(\beta - \alpha). \quad (6)$$

Differentiating both sides with respect to $(\beta - \alpha)$:

$$2z \frac{dz}{d(\beta - \alpha)} = 2RC \sin(\beta - \alpha) \frac{dz}{d(\beta - \alpha)} = \frac{RC}{z} \sin(\beta - \alpha). \quad (7)$$

Substituting (7) in (5):

$$\frac{\cos(\beta - \alpha)}{z} - \frac{RC \sin^2(\beta - \alpha)}{z^3} = \left(\frac{\cos \theta}{R} \right) \frac{d\theta}{d(\beta - \alpha)} \quad (8)$$

$$\frac{d\theta}{d(\beta - \alpha)} = \frac{R}{z \cos \theta} \left[\cos(\beta - \alpha) - \frac{RC}{z^2} \sin^2(\beta - \alpha) \right].$$

From (6):

$$\frac{z^2}{RC} = \frac{R}{C} + \frac{C}{R} - 2 \cos(\beta - \alpha). \quad (9)$$

From Fig. 6:

$$z \cos \theta = C - R \cos(\beta - \alpha). \quad (10)$$

Substituting (9) and (10) in (8):

$$\frac{d\theta}{d(\beta - \alpha)} = \frac{R}{C - R \cos(\beta - \alpha)} \left[\cos(\beta - \alpha) - \frac{\sin^2(\beta - \alpha)}{\frac{R}{C} + \frac{C}{R} - 2 \cos(\beta - \alpha)} \right]. \quad (11)$$

Simplifying:

$$\frac{\omega_B}{\omega_A} = \frac{d\theta}{d(\beta - \alpha)} = \frac{\cos(\beta - \alpha) - \frac{R}{C}}{\frac{R}{C} + \frac{C}{R} - 2 \cos(\beta - \alpha)}. \quad (12)$$

The above equation may also be derived as follows by a mathe-

mathematical solution of the distances x and y in Fig. 6, which, from our foregoing graphic solution, are inversely proportional to the angular velocities of links A and B.

By law of sines:

$$\frac{x}{-\cos \phi} = \frac{u}{\sin(\beta - \alpha)}; \quad (13)$$

$$\frac{y}{\sin 90^\circ} = \frac{u}{\sin \theta}. \quad (14)$$

Dividing (13) by (14):

$$\frac{x}{y} = \frac{-\sin \theta \cos \phi}{\sin(\beta - \alpha)}. \quad (15)$$

By law of cosines:

$$\begin{aligned} C^2 &= R^2 + z^2 - 2Rz \cos \phi \\ \therefore \cos \phi &= \frac{C^2 - R^2 - z^2}{-2Rz}. \end{aligned} \quad (16)$$

By law of sines:

$$\begin{aligned} \frac{R}{\sin \theta} &= \frac{z}{\sin(\beta - \alpha)}, \\ \therefore \sin \theta &= \frac{R \sin(\beta - \alpha)}{z}. \end{aligned} \quad (17)$$

Substituting (16) and (17) in (15):

$$\frac{x}{y} = \frac{(C^2 - R^2 - z^2)}{2z^2}. \quad (18)$$

By law of cosines:

$$z^2 = R^2 + C^2 - 2RC \cos(\beta - \alpha). \quad (19)$$

Substituting (19) in (18):

$$\frac{x}{y} = \frac{RC \cos(\beta - \alpha) - R^2}{R^2 + C^2 - RC \cos(\beta - \alpha)}. \quad (20)$$

Dividing both numerator and denominator by RC and simplifying:

$$\frac{\omega_B}{\omega_A} = \frac{x}{y} = \frac{\cos(\beta - \alpha) - \frac{R}{C}}{\frac{R}{C} + \frac{C}{R} - 2 \cos(\beta - \alpha)}. \quad (21)$$

The maximum instantaneous velocity ratio of $\frac{\omega_B}{\omega_A}$ occurs when

$(\beta - \alpha)$ equals zero. This value may be found by substitution in Eq 21 which gives:

$$\left(\frac{\omega_B}{\omega_A}\right)_{\text{max}} = \frac{R}{C - R}.$$

Acceleration Analysis.—Often of prime importance, particularly in the determination of inertia forces in high-speed mechanisms, is acceleration. As the magnitude of the inertia force is equal to the product of mass and acceleration, it often greatly exceeds the external load and is therefore the major factor in making a complete static and dynamic force analysis of the mechanism.

As the methods of solving acceleration problems are analogous to those employed for velocities, the direct vector method is usually the

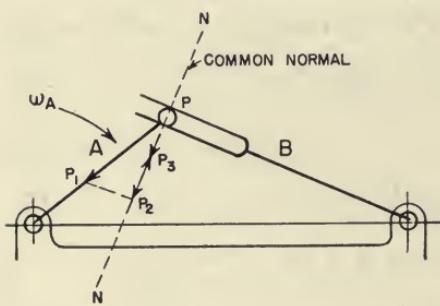


FIG. 7. Diagram used in acceleration analysis.

logical choice when an analysis is to be made at one instantaneous position of the mechanism. But in the Geneva mechanism shown, because of the sliding motion of one link on the other at the same time they are both rotating, an additional component of acceleration generally known as the Coriolis component must be added to

the normal and tangential components. Since this additional component complicates any complete graphic solution, the following method—a graphic method combined with a special computation—is usually preferred.

Represent the Geneva mechanism as shown in Fig. 7 and let:

ω_A = angular velocity of link A;

ω_B = angular velocity of link B;

α_A = angular acceleration of link A;

α_B = angular acceleration of link B;

a_A = tangential acceleration of link A;

a_B = tangential acceleration of link B;

V_R = velocity of point P on link A relative to point P on link B;

R = length of driver link A;

r = effective length of link B (at instant considered).

In the operation of the majority of these mechanisms, the driver link A rotates at a constant angular velocity. Assuming that ω_A

is constant, the tangential acceleration α_A of point P equals zero. The only effective acceleration P has is its normal acceleration relative to its fixed axis of rotation ϕ and is $a_A = \omega_A^2 R$. The direction is toward ϕ , and is represented by vector PP.

Draw a line through P, perpendicular to and intersecting common normal NN at P_2 . This component PP₂ acts in the direction shown and, according to Coriolis' law, equals the vector sum:

$$2V_R\omega_B = + \rightarrow R\alpha_B.$$

V_R may be obtained direct from the vector diagram in Fig. 3,

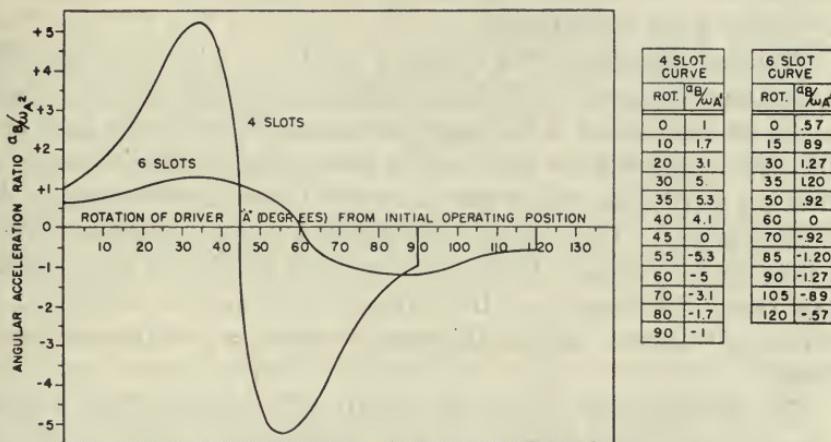


FIG. 8. Curve for obtaining acceleration ratio of Geneva mechanisms.

and ω_B by substitution of V_B and r (obtained from Fig. 3) in $\omega_B = \frac{V_B}{r}$. We may represent $2V_R\omega_B$ by P_2P_3 acting opposite to PP_1 in the direction shown:

$$\text{Since } PP_2 = 2V_R\omega_B + \rightarrow R\alpha_B;$$

$$PP_2 = P_2P_3 + \rightarrow R\alpha_B;$$

$$R\alpha_B = P_2P_3 - \rightarrow P_2P_3;$$

$$\therefore PP_3 = R\alpha_B.$$

Vector PP_3 is the resultant tangential component of the acceleration of P on link B; and since

$$a_B = \alpha_B r;$$

$$\alpha_B = \frac{a_B}{r} = \frac{PP_3}{r} \text{ in direction of } PP_2.$$

For a mathematical acceleration analysis, we may obtain the angular acceleration ratio of links A and B by differentiating ω_B/ω_A (obtained from Eq 12) with respect to time. Remembering ω_A is constant and that $\frac{d(\beta - \alpha)}{dt}$ is equal to ω_A , we obtain the following:

$$\frac{\alpha_B}{\omega_A^2} = \frac{\left(\frac{C}{R} - \frac{R}{C}\right)\sin(\beta - \alpha)}{\left[\frac{R}{C} + \frac{C}{R} - 2\cos(\beta - \alpha)\right]^2}. \quad (22)$$

Using this equation, the curves in Fig. 8 are obtained. These curves show the ratio of α_B/ω_A^2 for a 4- and 6-slot mechanism for complete cycles of operation.

Practical Design.—The designer of Geneva mechanisms first determines the number of slots required in the driven disk as indicated by the ratio it is necessary to achieve between the motion of the driver and driven shaft. The mechanism is then laid out so that the pin of the driver will enter and leave the slots at an angle of 90 degrees. If the mechanism operates at high speed or under a relatively heavy load, the points of maximum velocity and acceleration should be found, and the stress at these points checked to assure that it is not sufficiently great to prevent satisfactory operation.

The disadvantage in having points of relatively high angular velocity and acceleration in Geneva mechanisms is offset by the advantages gained in their simplicity of construction and reliability and accuracy in operation.

NOMENCLATURE FOR MOTION PICTURE FILM USED IN STUDIOS AND PROCESSING LABORATORIES*

Ed. Note.—The new American War Standard Nomenclature for Motion Picture Film Used in Studios and Processing Laboratories represents the first fruits of a unified effort to prepare a standard reference source for motion picture terminology. It was requested by the Armed Forces in order that a common understanding could be brought about within the motion picture industry and the Armed Forces as to what is meant by terms used daily in the production of picture and sound negatives and the related laboratory processes or methods employed in making the finished sound-film release prints exhibited in theaters or in the field to troops overseas.

The major part of this standard was drawn up by the subgroup on Nomenclature of Subcommittee C on Laboratory Practice of ASA War Committee on Photography and Cinematography, Z52, comprising Captain L. T. Goldsmith of the Signal Corps Photographic Center; D. E. Hyndman, president of the SMPE; W. F. Kelley, manager of the Research Council of the Academy of Motion Picture Arts and Sciences; and W. C. Miller, chairman of the Committee on Rerecording 35-Mm Features for 16-Mm Release of the Research Council of the Academy of Motion Picture Arts and Sciences.

The foreword, glossary, and production flow chart are reprinted here. Complete copies of the standard, including a list of personnel of War Committee on Photography and Cinematography, Z52, and Subcommittee C on 16-Mm Laboratory Practice, and index, may be obtained from the American Standards Association, 70 East 45th St., New York 17.

FOREWORD

This standard for motion picture film nomenclature has been prepared through the coordinated efforts of representatives of the motion picture industry, the Armed Forces, and the War Production Board.

It is not intended that it be a complete glossary. The main efforts of the committee have been devoted to obtaining general agreement for the first time on definitions of terms, materials, and processes now most widely used by studios and processing laboratories.

In this glossary the terms defined have been divided into various groups, and a flow chart showing the application of certain terms to the production of 35-mm and 16-mm release prints made from original

* American War Standard, Z52.14-1944; Approved December 29, 1944, by American Standards Association.

negatives has been included to facilitate its use by those not thoroughly familiar with the art.

Terms in which no reference is made to film size are understood to apply to both 16-mm and 35-mm films. All terms applicable to color films refer to color films of the monopack or integral tripack type.

Undoubtedly, there will be extensive constructive criticism and comment as a result of the use of this standard by the motion picture industry and the Armed Forces. At such time as sufficient comment has been received, this standard will be revised under the War Standards Procedure of the American Standards Association. In any event, after the war, this American War Standard will be reviewed through the regular procedure of the ASA and either approved as American Standard (possibly in amended form) or withdrawn.

Comments and criticisms should be addressed to MR. J. W. McNAIR, Secretary of the War Committee on Photography and Cinematography, Z52, American Standards Association, 70 East 45th St., New York 17, N. Y.

This standard has been developed under the supervision of the War Committee on Photography and Cinematography, Z52.

AMERICAN WAR STANDARD

NOMENCLATURE FOR MOTION PICTURE FILM USED IN STUDIOS AND PROCESSING LABORATORIES

1. General

1.1 Motion Picture Film. Motion picture film is a thin flexible ribbon of transparent material having perforations along one or both edges and bearing a sensitized layer or other coating capable of producing photographic images.

NOTE: The term "film" may be applied to unexposed film, to exposed but unprocessed film, and to exposed and processed film.

1.1.1 Raw Stock. Raw stock is film which has not been exposed or processed.

1.1.2 Film Base. Film base is the transparent or nearly transparent material upon which a photographic emulsion is coated; namely, the support for the emulsion in photographic film.

NOTE: All 35-mm film is usually understood to be an inflammable base (nitrate), unless otherwise specified.

1.1.2.1 Safety Base. Safety base is the slow burning film base used in motion picture film.

NOTE: At the present time, safety base and acetate base are synonymous and 16-mm film manufactured in the United States is of this form. All safety base must comply with American Recommended Practice for Motion Picture Safety Film, Z22.31-1941.

1.1.3 Film Perforations. Film perforations are the regularly and accurately spaced holes that are punched throughout the length of motion picture film. These holes are engaged by the teeth of various sprockets and pins by which the film is propelled and positioned as it travels through cameras, processing machines, projectors, and other film machinery.

1.1.3.1 35-Mm Negative Perforation. A 35-mm negative perforation is the perforation used for negative and some special-purpose 35-mm films.

NOTE: It is a perforation with sharp corners, curved sides and a straight top and bottom, and its dimensions are as shown in American Standard for Cutting and Perforating Negative Raw Stock, Z22.34-1944 or latest revision thereof.

1.1.3.2 35-Mm Positive Perforation. A 35-mm positive perforation is the perforation used for positive 35-mm film.

NOTE: This perforation is rectangular in shape with fillets in the corners, and its dimensions are as shown in American Standard for Cutting and Perforating Positive Raw Stock, Z22.36-1944 or latest revision thereof.

1.1.3.3 16-Mm Perforation. A 16-mm perforation is the perforation which is used in all 16-mm film.

NOTE: This perforation is rectangular in shape with fillets in the corners, and its dimensions are as shown in American Standard for Cutting and Perforating Negative and Positive 16-Mm Raw Stock, Z22.13-1944 or latest revision thereof.

1.1.4 Fine-Grain. Fine-grain is the term used to designate film emulsions in which the grain size is smaller or finer than in the older type emulsions commonly employed prior to about 1936.

NOTE: This term is relative as there is a wide variation in grain size among various fine-grain films. It is probable that the term will become obsolete when all film emulsions become fine grain. There is no inverse term such as coarse grain.

1.2 Direct Play-Back Positive. A direct play-back positive is a sound film which is so originally exposed that upon development in a single developer bath, the resulting image is in positive form available for normal sound reproduction.

NOTE: It is often a variable-area sound record.

1.3 Dupe (Duplicate) Negative. A dupe (duplicate) negative is a negative film that is produced by printing from a positive.

NOTE: A dupe negative is used for producing prints which are, in effect, duplicates of prints which might be made from the original negative.

1.3.1 Temporary Picture Dupe Negative. A temporary picture dupe negative is a low-quality dupe negative and is made on positive stock.

NOTE: It is used to make low-quality prints for use in editing. It usually contains picture only, but may also have the sound track on the same film.

1.3.2 Print from a Temporary Picture Dupe Negative. A print from a temporary picture dupe negative is a low-quality print made from the temporary picture dupe negative.

1.4 Image (Photographic). An image is any photographically obtained likeness on a film emulsion.

1.4.1 Latent Image. A latent image is the invisible image registered on a photographic emulsion due to the reaction produced in the emulsion by exposure to light.

NOTE: This image becomes visible after development.

1.4.2 Picture Image. A picture image is a photographically obtained likeness of any object on photographic film.

1.4.3 Sound Image. A sound image is a photographically obtained sound track or sound record.

1.4.4 Negative Image. A negative image is a photographic image in which the values of light and shade of the original photographed subject are represented in inverse order.

NOTE: In a negative image, light objects of the original subject are represented by high densities and dark objects are represented by low densities.

1.4.5 Positive Image. A positive image is a photographic replica in which the values of light and shade of the original photographed subject are represented in their natural order.

NOTE: In a positive image, the light objects of the original subject are represented by low densities and the dark objects are represented by high densities.

1.5 Synchronism. Synchronism is the relation between the picture and sound films with respect either to the physical location on the film or films, or to the time at which corresponding picture and sound are seen and heard.

1.5.1 *Projection Synchronism.* Projection synchronism is the time relation between picture and corresponding sound in a projection print.

NOTE: Correct projection synchronism is indicated by exact coincidence of picture and sound as seen and heard. To attain this result, it is necessary to place the sound track 20 frames ahead of the center of the corresponding picture for 35-mm film and 26 frames ahead of the center of the corresponding picture for 16-mm film, since sound motion picture projection equipment is designed for projection synchronism with this relationship existing between the locations of the projected picture and corresponding sound.

1.5.2 *Editorial Synchronism.* Editorial synchronism is the relationship between the picture and sound film during the editorial processes.

NOTE: During the editorial process, the sound track and corresponding picture, whether on the same or separate films, are kept in alignment and not offset as for projection. Thus, cutting a picture and sound can be a simultaneous operation. Many composite release negatives are supplied in editorial synchronism.

1.5.3 *Camera Synchronism.* Camera synchronism is the relationship between picture and sound on an original composite negative.

NOTE: Camera synchronism is generally not the same as projection synchronism and is never the same as editorial synchronism. The relationship between picture and sound may vary among different type cameras.

1.6 *Exposure.* Exposure is the process of subjecting a photographic film to any given intensity of light in such a manner that it may produce a latent image on the emulsion.

1.7 *Development.* Development is the process of treating an exposed photographic emulsion to make the latent image visible.

NOTE: This term is sometimes incorrectly used in the trade to include both fixation and washing of the developed image and drying of the film. The correct term for these operations as a group is processing.

1.7.1 *Fixing (Fixation).* Fixing (fixation) is the process of removing the residual sensitive silver halides from a developed film to render the developed image permanent.

NOTE: During the process of fixation, films are customarily treated to preserve and harden the developed image.

1.8 *Printing.* Printing is the process of exposing raw stock by using the image of another film as the light modulator.

NOTE: Through printing, one may produce a positive print from a negative

film; a negative film from a positive film; or, if the reversal process is employed, printing may be used to produce positives from positives or negatives from negatives. When the verb "to print" is used, any of the above processes may be implied.

1.8.1 Contact Printing. Contact printing is that method of printing in which the raw stock is held in intimate contact with the film bearing the image to be copied.

1.8.2 Projection Printing (Optical Printing). Projection printing (optical printing) is printing by projecting the image to be copied on the raw stock.

NOTE: When projection printing, the image being copied may be enlarged, reduced, or made the same size.

1.8.2.1 Reduction Printing. Reduction printing is the process of producing and recording photographically a smaller image, usually on a smaller film, from a larger image.

NOTE: This process is commonly used in making 16-mm negatives or prints from 35-mm originals. Film thus made is referred to as a reduction negative or reduction print, as the case may be.

1.9 Projection. Projection is the process of presenting a film for either visual or aural review, or both.

1.10 Production. Production is the general term used to describe the processes involved in making all the original material that is the basis for the finished motion picture.

1.11 Editorial Process. Editorial process is the term used to describe the combining, cutting, editing, and other preparation of material obtained from the original material to make the finished motion picture.

1.12 Rerecording. Rerecording is the electrical process of transferring sound records from one or more films or disks to other films or disks.

NOTE: Rerecording may be used to combine different sound records into a single record; to adjust the response-frequency characteristic; or to adjust the relative levels between different scenes and sequences.

1.13 Release. Release is a generic term used to designate films used for or intended for general distribution and exhibition.

NOTE: Unless specifically stated, release refers only to the normal or domestic release of 35-mm motion picture production through agencies within the United States.

1.13.1 16-Mm Release. A 16-mm release designates any or all the releases made on 16-mm film.

1.13.2 Foreign Release. A foreign release is any release made to agencies outside the United States.

NOTE: A descriptive adjective is usually applied to name the specific country or territory to which the release will go. As an example, a release made to Spain would be termed a Spanish release.

1.13.2.1 16-Mm Foreign Release. A 16-mm foreign release is a foreign release made on 16-mm film.

NOTE: As an example, a release made to Spain on 16-mm film would be termed a 16-mm Spanish release.

1.13.3 Release Negative. A release negative is a complete negative prepared specifically for printing release prints.

NOTE: A release negative may consist of separate picture and sound negatives and may be in either projection or editorial synchronism, depending upon the film processing technique to be employed in making release prints.

1.14 35-Mm Negative Blow-up. A 35-mm negative blow-up is a negative made by the optical printing process in which a larger negative image is produced from a smaller positive image.

NOTE: 35-mm negative blow-ups may be made from a 16-mm or possibly an 8-mm positive by the use of the optical printing process.

1.15 Matte Rolls (Traveling Masks). Matte rolls (traveling masks) are a pair of film rolls used as light modulators.

NOTE: Matte rolls are complementary in that where one roll is clear, the other is effectively opaque. They are usually matched to rolls of original black and white, or of color reversal positives in the printing of black and white or color duplicates.

2. Negative Film

2.1 Negative. The term "negative" is used to designate any of the following:

- (a) the raw stock specifically designed for negative images
- (b) the negative image
- (c) negative raw stock which has been exposed but has not been processed
- (d) film bearing a negative image which has been processed.

2.2 Picture Negative. A picture negative is any negative film which, after exposure to a subject or positive image and subsequent processing, produces a negative picture image on the film.

2.2.1 Original Picture Negative. The original picture negative is the negative film which is exposed in the camera and subsequently processed to produce an original negative picture image.

2.2.2 Background Plate Negative. A background plate negative is a picture negative which is used to print background plates.

2.2.3 Picture Library Negative. A picture library negative is a picture negative which is usually held in a stock library for use in reproducing scenes which would otherwise have to be made as original material for each production.

2.2.4 Title Negative. A title negative is a picture negative which is exposed to a title card or to both a title card and background.

2.2.5 Picture Dupe Negative. A picture dupe negative is a picture negative made from a picture duping print.

NOTE: It may be used for making other picture prints or may be cut to form a part of the picture release negative.

2.2.6 Picture Release Negative. A picture release negative is a release negative used for printing the picture portion of release prints.

NOTE: It may consist of intercut original picture negatives, picture dupe negatives, etc., depending upon the choice of available material or the intended use of the release print.

2.2.7 Foreign Picture Release Negative. A foreign picture release negative is a picture release negative prepared specifically for printing foreign version release prints.

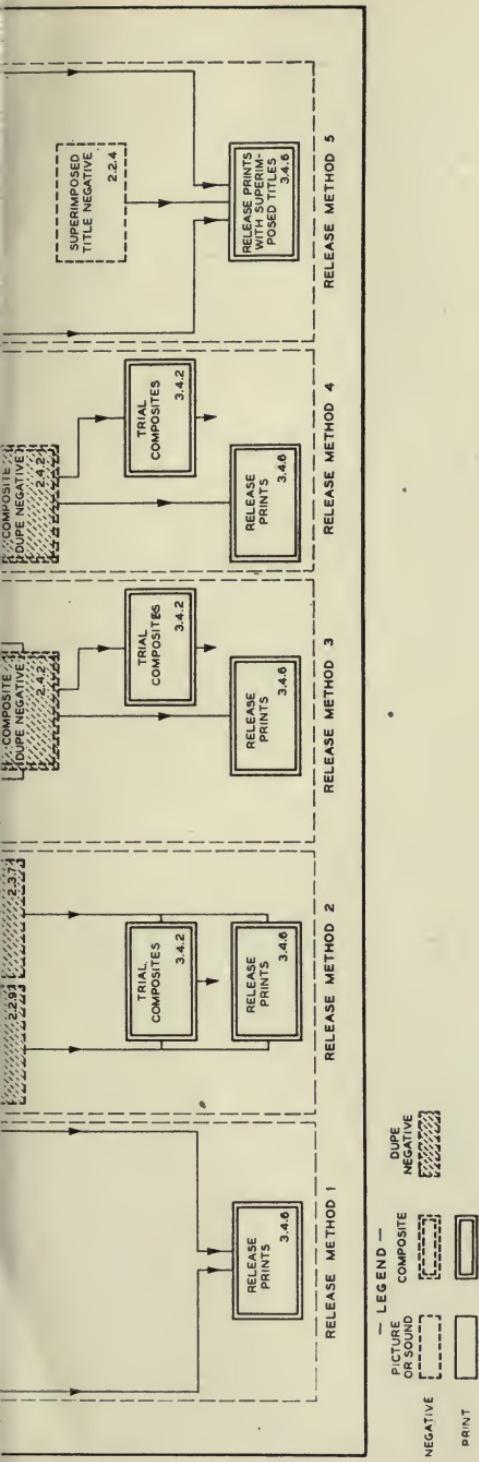
NOTE: It is almost invariably a dupe negative.

2.2.8 16-Mm Picture Release Negative. A 16-mm picture release negative is a picture release negative on 16-mm film prepared specifically for printing 16-mm release prints.

NOTE: It is generally a dupe negative.

2.2.9 Picture Release Dupe Negative. A picture release dupe negative is a picture dupe negative prepared specifically for printing the picture portion of release prints.

2.3 Sound Negative. A sound negative is any negative film which, after exposure to a positive sound image and subsequent processing, produces a negative sound track on the film.



Note 1. The SPECIAL SOUND RELEASE NEGATIVE is substituted for the SOUND RELEASE NEGATIVE when making special version release prints, such as FOREIGN VERSION RELEASE, 16-MM RELEASE, etc.

Note 2. In release method 1, a PICTURE MASTER POSITIVE and a SOUND MASTER POSITIVE are always made prior to release printing.

Note 3. In release methods 2, 3, and 4, dupe negatives may be either reduction dups or a dupe from a 16-mm negative, if release is to be made on 16-mm film. When a limited number of 16-mm prints are to be made, 16-MM RELEASE PRINTS are sometimes made directly from the 35-mm negative by optical reduction printing.

Note 4. In release method 5, RELEASE PRINTS (with superimposed titles) are usually made when all other release print work has been completed.

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2.3.1 Original Sound Negative. The original sound negative is the sound negative which is exposed in a film recorder and after processing produces a negative sound image on the film.

2.3.2 Sound Effects Negative. A sound effects negative is a sound negative upon which sound effects have been recorded.

NOTE: It is ordinarily held in library stock.

2.3.3 Music Negative. A music negative is a sound negative upon which music has been recorded.

NOTE: It is usually an original sound negative but may be a library negative.

2.3.4 Sound Cut Negative. A sound cut negative is a sound negative which is intercut from an original sound negative.

NOTE: It is generally in exact conformity with the sound work print, and produces a single combined negative. The print of the sound cut negative provides all, or portions of, the rerecording print.

2.3.5 Rerecorded Negative. A rerecorded negative is a sound negative which is exposed by rerecording and when processed produces a negative sound-track image.

2.3.6 Sound Release Negative. A sound release negative is a release negative prepared for printing the sound portion of release prints.

NOTE: It may consist of rerecorded negatives, intercut original sound negatives, sound dupe negatives, etc., depending upon the choice of available material or the intended use of the print.

2.3.6.1 Special Sound Release Negative. A special sound release negative is a sound release negative made for the purpose of obtaining a sound track which has characteristics other than the sound release negative.

NOTE: It may be a sound track for use in foreign version release, foreign English language version release, or 16-mm release from 35-mm original material. It usually has undergone an additional rerecording operation.

2.3.6.1a Special Sound Release Negative for Use in 16-Mm Release of 35-Mm Preprint Material. The special sound release negative for 16-mm release of 35-mm original material is usually rerecorded.

NOTE: It may be rerecorded from a print of the 35-mm sound release negative or from the 35-mm rerecording print.

2.3.6.1b Special Sound Release Negative Used in English Version for Foreign Release. The special sound release negative for

use in English version for foreign release is rerecorded from the re-recording print, except that the dialogue track is modified to remove American colloquialism.

2.3.6.1c Special Sound Release Negative Used in Foreign Language Version. The special sound release negative for use in foreign language version release is usually rerecorded using all of rerecording tracks, except the dialogue track for which is substituted a special synchronized dialogue track in the foreign language for which the release is being made.

2.3.7 Sound Release Dupe Negative. A sound release dupe negative is a sound dupe negative prepared specifically for printing the sound track of release prints.

2.4 Composite Negative. A composite negative is a negative film which is exposed and processed to produce both sound track and picture negative images on the same film.

NOTE: The sound and picture may be in editorial, projection or camera synchronization, depending upon the manner in which the composite negative is made and its intended use.

2.4.1 Composite Original Negative. A composite original negative is a composite negative which, after exposure and processing, produces an original negative picture and sound track image in camera synchronization.

2.4.2 Composite Dupe Negative. A composite dupe negative is a composite negative which, after exposure and processing, produces a dupe negative picture and sound track image.

NOTE: It is usually used for printing foreign version release prints and is frequently in editorial synchronization.

3. Positive Film

3.1 Print or Positive. The term "positive" or "print" is used to designate any of the following:

- (a) the raw stock specifically designed for positive images
- (b) the positive image
- (c) positive raw stock which has been exposed but has not been processed
- (d) film bearing a positive image which has been processed.

3.2 Picture Print. A picture print is any positive printed from a picture negative.

3.2.1. Picture Daily Print. A picture daily print is the first picture print made from the original picture negative for use in checking photographic quality, camera technique, *etc.*

3.2.2 Picture Work Print. A picture work print is a positive print which usually consists of intercut picture daily prints, picture library prints, prints of dissolves, montages, titles, *etc.*, and has synchronism constantly maintained with the corresponding sound work print.

NOTE: A picture work print is used to edit and combine the various picture scenes of a motion picture into the desired form.

3.2.3 Picture Library Print. A picture library print is a picture print made from a picture library negative.

3.2.4 Background Plate (Background Film). A background plate (background film) is a picture print made specifically for use in projection backgrounds or similar process work, and is a print of a background plate negative.

NOTE: Background plates are usually made on special stock having negative perforations.

3.2.5. Picture Duping Print.* A picture duping print is a picture print made on a special film for the purpose of producing a duplicate negative or for producing dissolves, montages, titles, *etc.*

NOTE: Duping print is synonymous with master positive except that duping print is the term used in the editorial process, while master positive is used in release.

3.2.5.1 Picture Master Positive. A picture master positive is a picture duping print usually made for the purpose of producing a picture dupe negative for release printing.

3.2.6. Print from Picture Dupe Negative. A print from a picture dupe negative is any print made from a picture dupe negative, and is usually a projection print used for editorial purposes.

3.2.7. Picture Check Print. A picture check print is a picture print made from the picture release negative for the purpose of checking negative cutting, printing lights, picture quality, *etc.*

NOTE: When a picture check print is required, it is usually made prior to the first trial composite print.

3.3 Sound Print. A sound print is any positive printed from a sound negative.

3.3.1 Sound Daily Print. A sound daily print is the first sound print made from the original sound negative for checking sound quality, technique, etc.

3.3.2 Sound Work Print. A sound work print is a sound print which usually consists of intercut sound daily prints, but may also include other sound tracks of sound effects or music, or both, on the same or separate films with synchronism constantly maintained with the corresponding picture work print.

3.3.3 Sound Effects Print. A sound effects print is a sound print made from a sound effects negative.

3.3.4 Music Print. A music print is a sound print made from a music negative.

3.3.5 Rerecording Print. A rerecording print is a sound print prepared specifically for use in rerecording to produce a rerecorded negative.

NOTE: It may be a print from a sound cut negative, a specially intercut print, or a combination of both. A rerecording print may consist of several sound records on separate films including dialogue, sound effects, music or any other required material. The term is used interchangeably to designate the entire group of associated films or any individual film which is part of the group.

3.3.6 Rerecorded Print. A rerecorded print is a sound print from a rerecorded sound track negative.

3.3.7 Sound Check Print. A sound check print is a sound print made from the sound release negative for the purpose of checking negative cutting, printing lights, sound quality, etc.

NOTE: When a sound check print is required, it is usually made prior to the first trial composite print.

3.3.8 Sound Master Positive. A sound master positive is a sound print on special film stock and is usually made from a sound release negative for the purpose of producing sound dupe negatives for release printing.

3.4 Composite Print. A composite print is a positive film having both picture and sound track images on the same film which may be in editorial or projection synchronism.

3.4.1 Composite Daily Print. A composite daily print is the first print made from an original composite negative or an original sound and picture negative, and is used for checking photography, sound quality, action, *etc.* It is in projection synchronism.

3.4.2 First Trial Composite Print. The first trial composite is the first composite print made from the picture and sound release negatives for the purpose of checking and correcting picture and sound quality, negative cutting and assembly, *etc.* It is in projection synchronism.

3.4.3 Second, Third, etc., Trial Composite Print. The second, third, *etc.*, trial composite print is similar to the first trial composite print but has successive corrections incorporated as a result of viewing the previous trial composite prints.

3.4.4 Final Trial Composite (Sample Print). A final trial composite (sample print) is a composite print, approved for release, in which all corrections found necessary in previous trial composite prints have been incorporated.

NOTE: The final trial composite may be any one of the various trial composite prints, depending upon the type and extent of corrections required.

3.4.5 Composite Master Positive. A composite master positive is a composite print usually made for the purpose of producing composite or picture and sound dupe negatives which would be used for printing release prints.

NOTE: It is usually made on duplicating raw stock and may be in either editorial or projection synchronism.

3.4.6 Release Print. A release print is a composite print made for general distribution and exhibition after the final trial composite or sample print has been approved. It is in projection synchronism.

3.4.6.1 Foreign Version Release Prints. Foreign version release prints are composite prints in projection synchronism and are made specifically for the particular version involved.

3.4.7 Foreign Version Trial Composite Prints. Foreign version trial composite prints are similar to trial composite prints made during release except that they are made for checking the release of the particular version involved.

4. Color and Reversal Film Terms

4.1 Reversal Film. A reversal film is one which after exposure is processed to produce a positive image on the same film rather than



FIG. 1. Editing motion picture film for Army use at Signal Corps Photographic Center.

the customary negative image. If exposure is made by printing from a negative, a negative image is produced directly.

NOTE: Reversal films may be black and white, or color, and either sound or picture or both, and they are usually 16-mm films.

4.2 Reversal Process. The reversal process is the photographic process which reversal films undergo. It is a process in which a latent image is developed to a silver image by primary development, destroyed by a chemical bleach, and the remaining sensitized mate-

rial exposed and developed in a second developer bath before fixing and washing.

4.3 Reversal Original. A reversal original is the film which is originally exposed in a camera or recorder and is processed by reversal to produce a positive image.

NOTE: This positive image is not the same as a print from a negative inasmuch as right and left are transposed. A reversal original may be a black and white, or color, film.

4.3.1 Composite Reversal Original. A composite reversal original is a reversal original which has both picture and sound on the same film.

4.3.2 Original Color Positive. An original color positive is a color reversal original which is developed by the reversal process to produce a positive color image.

4.3.3 Composite Original Color Positive. A composite original color positive is an original color positive with sound track and picture on the same film.

4.4 Dupe Negative from Original Reversal, 16-Mm. A dupe negative from an original reversal is a negative made from an original reversal positive or an original color positive. The image on such a dupe negative is not transposed right to left. It is usually used to make black and white prints.

4.5 Reversal Print. A reversal print is a print which is made on reversal film and developed by the reversal process.

NOTE: A reversal print is usually a positive.

4.5.1 Reversal Dupe Print, 16-Mm. A reversal dupe print is a reversal print which is printed from a black and white, or color, reversal original and processed by reversal to obtain a positive black and white image.

4.5.2 Color Dupe Print. A color dupe print is a color reversal which is printed from a color reversal original and processed to obtain a positive color image.

4.5.3 Composite Color Dupe Print. A composite color dupe print is a print made from an original composite color positive or from an original picture color positive and a sound track, and is

processed to obtain a positive color print of both picture and sound track.

4.5.4 Composite Reversal Dupe Print, 16-Mm. A composite reversal dupe print is a reversal dupe print having both picture and sound tracks on the same film.

4.5.5 Reduction Reversal Print, 16-Mm. A reduction reversal print is a reversal print made on 16-mm reversal film from a 35-mm positive by reduction printing and development by the reversal process.

4.5.6 Reversal Master Print, 16-Mm. A reversal master print is a 16-mm reversal print made specifically for use in producing other prints.

NOTE: It is sometimes referred to as a first generation dupe, prints from it then being referred to as second generation dupes.

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**F. L. EICH

*C. O. SLYFIELD

*W. R. WILKINSON

* Term expires December 31, 1945.

** Term expires December 31, 1946.

COMMITTEES OF THE SOCIETY

(Correct to March 15, 1945)

ADMISSIONS.—To pass upon all applications for membership, applications for transfer and to review the Student and Associate membership list periodically for possible transfers to the Associate and Active grades, respectively. The duties of each committee are limited to applications and transfers originating in the geographic area covered.

(*East Coast*)

A. S. DICKINSON, *Chairman*
28 West 44th St.
New York 18, N. Y.

M. R. BOYER
F. E. CAHILL, JR.

JAMES FRANK, JR.
J. A. MAURER

HARRY RUBIN
E. I. SPONABLE

(*West Coast*)

H. W. REMERSCHEID, *Chairman*
8339 Sunset Blvd.
Hollywood, Calif.

C. R. DAILY
EMERY HUSE

PETER MOLE
H. W. MOYSE

BOARD OF EDITORS.—To pass upon the suitability of all material submitted for publication, or for presentation at conventions, and publish the JOURNAL.

A. C. DOWNES, *Chairman*
Box 6087
Cleveland 1, Ohio

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A. M. GUNDELFINGER
C. W. HANDLEY
A. C. HARDY

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E. W. KELLOGG

CINEMATOGRAPHY.—To survey the field of motion picture photography in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

J. W. BOYLE, *Chairman*
1207 N. Mansfield Ave.
Hollywood, Calif.

C. G. CLARKE
KARL FREUND

*ARTHUR MILLER

ARTHUR REEVES
JOSEPH RUTTENBERG

COLOR.—To survey the field of color in motion picture photography in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

J. A. BALL, *Chairman*
Parlin, N. J.
(Under Organization)

* Advisory Member.

CONVENTION.—To assist the Convention Vice-President in the responsibilities pertaining to arrangements and details of the Society's technical conventions.

W. C. KUNZMANN, *Chairman*
Box 6087
Cleveland 1, Ohio

*JULIUS HABER
H. F. HEIDEGGER

C. R. KEITH
R. H. McCULLOUGH

H. W. MOYSE
O. F. NEU

EXCHANGE PRACTICE.—To survey the field of exchange practice in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

(Under Organization)

FELLOW MEMBERSHIP.—To consider qualifications of Active members as candidates for elevation to Fellow members, and to submit such nominations to the Board of Governors.

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HISTORICAL AND MUSEUM.—To collect facts and assemble data relating to the historical development of the motion picture industry, to encourage pioneers to place their work on record in the form of papers for publication in the JOURNAL, and to place in suitable depositories equipment pertaining to the industry.

J. E. ABBOTT, *Chairman*
11 West 53d St.
New York 19, N. Y.

O. B. DEPUE

RICHARD GRIFFITH

TERRY RAMSAYE

HONORARY MEMBERSHIP.—To diligently search for candidates who through their basic inventions or outstanding accomplishments have contributed to the advancement of the motion picture industry and are thus worthy of becoming Honorary members of the Society.

EMERY HUSE, *Chairman*
6706 Santa Monica Blvd.
Hollywood 38, Calif.

NATHAN LEVINSON
A. J. MILLER

L. L. RYDER
E. I. SPONABLE

JOURNAL AWARD.—To recommend to the Board of Governors the author or authors of the most outstanding paper originally published in the JOURNAL during the preceding calendar year to receive the Society's Journal Award.

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Nela Park
Cleveland 12, Ohio

C. R. DAILY
P. J. LARSEN

G. E. MATTHEWS
W. V. WOLFE

LABORATORY PRACTICE.—To survey the field of motion picture laboratory practice in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

H. E. WHITE, *Chairman*
Room 813
350 Madison Ave.
New York 17, N. Y.

* Advisory Member.

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MEMBERSHIP AND SUBSCRIPTION.—To solicit new members, obtain nonmember subscriptions for the JOURNAL, and to arouse general interest in the activities of the Society and its publications.

JAMES FRANK, Jr., *Chairman*
356 West 44th St.
New York 18, N. Y.

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J. P. CORCORAN	S. A. LUKES	W. V. WOLFE
J. G. FRAYNE	G. E. MATTHEWS	C. R. WOOD, SR.
	G. C. MISENER	

NOMINATIONS.—To recommend nominations to the Board of Governors for annual election of officers and governors.

E. M. HONAN, *Chairman*
6601 Romaine St.
Hollywood 38, Calif.

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HERBERT GRIFFIN	J. A. MAURER	E. A. WILLIFORD

NONTHEATRICAL EQUIPMENT.—To survey the field of nontheatrical motion picture equipment in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

D. F. LYMAN, *Chairman*
1368 Titus Ave.
Rochester 9, N. Y.

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PAPERS.—To solicit papers, and provide the program for semi-annual conventions, and make available to local sections for their meetings papers presented at national conventions.

C. R. DAILY, *Chairman*
5451 Marathon St.
Hollywood 38, Calif.

BARTON KREUZER, *Vice-Chairman*
RCA Victor Division
Radio Corp. of America
Camden, N. J.

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*Advisory Member.

PRESERVATION OF FILM.—To survey the field for methods of storing and preserving motion picture film in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

J. G. BRADLEY, *Chairman*
The National Archives
Washington 25, D. C.

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*H. T. COWLING
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J. L. FORREST
*J. E. GIBSON
*ORVILLE GOLDNER

C. L. GREGORY
*W. F. KELLEY
TERRY RAMSAYE
V. B. SEASE

PROCESS PHOTOGRAPHY.—To survey the field of process photography in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

(Under Organization)

PROGRESS.—To prepare an annual report on progress in the motion picture industry.

G. A. CHAMBERS, *Chairman*
Naval Air Station, PSL
Anacostia, D. C.

F. T. BOWDITCH
G. L. DIMMICK

J. A. DUBRAY
M. S. LESHING

G. E. MATTHEWS
D. R. WHITE

PROGRESS MEDAL AWARD.—To recommend to the Board of Governors a candidate who by his inventions, research, or development has contributed in a significant manner to the advancement of motion picture technology, and is deemed worthy of receiving the Progress Medal Award of the Society.

E. A. WILLIFORD, *Chairman*
230 Park Ave.
New York 17, N. Y.

M. R. BOYER
F. E. CARLSON

NATHAN LEVINSON
G. F. RACKETT

PUBLICITY.—To assist the Convention Vice-President in the release of publicity material concerning the Society's semi-annual technical conventions.

*JULIUS HABER, *Chairman*
RCA Victor Division
Radio Corp. of America
Camden, N. J.

*LEONARD BIDWELL
*E. O. BLACKBURN

C. R. DAILY
BARTON KREUZER

P. A. MCGUIRE
HARRY SHERMAN

SOUND.—To survey the field of motion picture sound recording and reproducing in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

J. G. FRAYNE, *Chairman*
6601 Romaine St.
Hollywood 38, Calif.

C. R. KEITH, *Vice-Chairman*
233 Broadway
New York 7, N. Y.

(Under Organization)

STANDARDS.—To survey the various fields or branches of the motion picture industry in an endeavor to bring before the Society any information on current or future practice or methods that would lead to possibilities of standardization of any specific procedure.

F. T. BOWDITCH, *Chairman*
Box 6087
Cleveland 1, Ohio

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A. F. EDOUART	PIERRE MERTZ	A. G. ZIMMERMAN
	W. C. MILLER	

STUDIO LIGHTING.—To survey the field of motion picture studio lighting in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

C. W. HANDLEY, *Chairman*
1960 West 84th St.
Los Angeles 44, Calif.

J. W. BOYLE
H. J. CHANON

R. E. FARNHAM

KARL FREUND
W. W. LOZIER

TECHNICAL NEWS.—To survey the fields of production, distribution, and exhibition of motion pictures, and allied industries, to obtain technical news items for publication in the JOURNAL.

A. C. BLANEY, *Chairman*
1016 N. Sycamore St.
Hollywood 38, Calif.

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J. I. CRABTREE
A. M. GUNDELFINGER

C. W. HANDLEY
EMERY HUSE
H. R. LUBCKE
K. F. MORGAN

H. W. REMERSCHEID
EDWARD SCHMIDT
WILLIAM THOMAS

TELEVISION.—Technical consideration of the uses of motion picture television service, technical consideration of the phases of television which affect origination, transmission, distribution, and reproduction of theater television.

(Under Organization)

TEST FILM QUALITY.—To supervise the quality of prints of test films prepared by the Society.

F. R. WILSON, *Chairman*

C. F. HORSTMAN

THEATER ENGINEERING.—The Committee on Theater Engineering comprises the membership of the 4 subcommittees listed below and is under the general chairmanship of DR. ALFRED N. GOLDSMITH, 597 Fifth Ave., New York 17, N. Y.

Subcommittee on Film Projection Practice.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture projection equipment, projection rooms, film storage facilities, and stage arrangements as they affect screen dimensions, placement, and the maintenance of loudspeakers.

M. F. BENNETT, *Chairman*
D. W. COLLINS, *Secretary*
321 West 44th St.
New York 18, N. Y.

* Advisory Member.

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 *C. J. BACHMAN
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 KARL BRENKERT
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 E. R. MORIN
 M. D. O'BRIEN
 HARRY RUBIN
 J. J. SEFING
 R. O. WALKER
 V. A. WELMAN
 H. E. WHITE

Subcommittee on Television Projection Practice.—To make recommendations and prepare specifications for the construction, installation, maintenance, and servicing of equipment for projecting television pictures in the theater, as well as the projection room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in theater television presentation.

P. J. LARSEN, *Chairman*
 1401 Sheridan St., N. W.
 Washington 11, D. C.

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 *H. E. BRAGG†
 *C. S. SZEGHO
 NICHOLAS GLYPTIS†
 H. E. WHITE
 D. E. HYNDMAN†

Subcommittee on Screen Brightness.—To make recommendations, prepare specifications and test methods for determining and standardizing the brightness of the motion picture screen image at various parts of the screen, and for specific means or devices in the projection room adapted to the control or improvement of screen brightness.

F. E. CARLSON, *Chairman*
 Nela Park
 Cleveland 12, Ohio

HERBERT BARNETT
 SYLVAN HARRIS
 W. F. LITTLE

W. B. RAYTON
 C. M. TUTTLE

H. E. WHITE
 A. T. WILLIAMS
 R. J. ZAVESKY

Subcommittee on Theater Engineering, Construction, and Operation.—To deal with the technical methods and equipment of motion picture theaters in relation to their contribution for the physical comfort and safety of patrons so far as can be enhanced by correct theater design, construction, and operation of equipment.

HENRY ANDERSON, *Chairman*
 1501 Broadway
 New York 18, N. Y.

HERBERT BARNETT
 F. E. CARLSON
 *W. B. CUTTER
 *W. L. FLEISHER

JAMES FRANK, JR.
 T. T. GOLDSMITH
 J. J. HOPKINS

C. F. HORSTMAN
 E. R. MORIN
 BEN SCHLANGER
 J. J. SEFING

* Advisory Member.
 † Alternate.

SMPE REPRESENTATIVES TO OTHER ORGANIZATIONS

<i>American Documentation Institute</i>	J. E. ABBOTT
<i>American Standards Association:</i>	
<i>Sectional Committee on Standardization of Letter Symbols and Abbreviations for Science and Engineering, Z10</i>	L. A. JONES
<i>Sectional Committee on Motion Pictures, Z22 (Chairman being elected and committee organized.)</i>	
<i>Sectional Committee on Acoustical Measurements and Terminology, Z24</i>	J. E. VOLKMANN
<i>Sectional Committee on Photography, Z38</i>	J. I. CRABTREE
<i>War Committee on Photography and Cinematog- raphy, Z52</i>	D. E. HYNDMAN E. A. WILLIFORD†
<i>European Advisory Committee</i>	DONALD McMASTER, Chm.
<i>Inter-Society Color Council</i>	R. M. EVANS, Chm. J. A. BALL M. R. BOYER A. M. GUNDELFINGER G. F. RACKETT P. J. LARSEN E. I. SPONABLE†
<i>Radio Technical Planning Board</i>	

† Alternate.

CONSTITUTION AND BY-LAWS
OF THE
SOCIETY OF MOTION PICTURE ENGINEERS*

CONSTITUTION

Article I

Name

The name of this association shall be SOCIETY OF MOTION PICTURE ENGINEERS.

Article II

Object

Its objects shall be: Advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the equipment, mechanisms, and practices employed therein, the maintenance of a high professional standing among its members, and the dissemination of scientific knowledge by publication.

Article III

Eligibility

Any person of good character may be a member in any grade for which he is eligible.

Article IV

Officers

The officers of the Society shall be a President, a Past-President, an Executive Vice-President, an Engineering Vice-President, an Editorial Vice-President, a Financial Vice-President, a Convention Vice-President, a Secretary, and a Treasurer.

The term of office of the President, the Past-President, the Executive Vice-President, the Engineering Vice-President, the Editorial Vice-President, the Financial Vice-President, and the Convention Vice-President shall be two years, and the Secretary and the Treasurer one year. Of the Engineering, Editorial, Financial, and Convention Vice-Presidents, two shall be elected alternately each year, or until their successors are chosen. The President shall not be immediately eligible to succeed himself in office. Under such conditions as set forth in the By-Laws the office of Executive Vice-President may be vacated before the expiration of his term.

Article V

Board of Governors

The Board of Governors shall consist of the President, the Past-President, the five Vice-Presidents, the Secretary, the Treasurer, the Section Chairmen and

* Corrected to March 15, 1945.

ten elected governors. Five of these governors shall be resident in the area operating under Pacific and Mountain time, and five of the governors shall be resident in the area operating under Central and Eastern time. Two of the governors from the Pacific area and three of the governors from the Eastern area shall be elected in the odd-numbered years, and three of the governors in the Pacific area and two of the governors in the Eastern area shall be elected in the even-numbered years. The term of office of all elected governors shall be for a period of two years.

Article VI

Meetings

There shall be an annual meeting, and such other meetings as stated in the By-Laws.

Article VII

Amendments

This Constitution may be amended as follows: Amendments shall be approved by the Board of Governors, and shall be submitted for discussion at any regular members' meeting. The proposed amendment and complete discussion then shall be submitted to the entire Active, Fellow, and Honorary membership, together with letter ballot as soon as possible after the meeting. Two-thirds of the vote cast within sixty days after mailing shall be required to carry the amendment.

BY-LAWS

By-Law I

Membership

Sec. 1.—The membership of the Society shall consist of Honorary members, Fellows, Active members, Associate members, Student members, and Sustaining members.

An Honorary member is one who has performed eminent services in the advancement of motion picture engineering or in the allied arts. An Honorary member shall be entitled to vote and to hold any office in the Society.

A Fellow is one who shall not be less than thirty years of age and who shall comply with the requirements of either (a) or (b) for Active members and, in addition, shall by his proficiency and contributions have attained to an outstanding rank among engineers or executives of the motion picture industry. A Fellow shall be entitled to vote and to hold any office in the Society.

An Active member is one who shall be not less than 25 years of age, and shall be (a) a motion picture engineer by profession. He shall have been engaged in the practice of his profession for a period of at least three years, and shall have taken responsibility for the design, installation, or operation of systems or apparatus pertaining to the motion picture industry; (b) a person regularly employed in motion picture or closely allied work, who by his inventions or proficiency in motion picture science or as an executive of a motion picture enterprise of large scope, has attained to a recognized standing in the motion picture industry.

In case of such an executive, the applicant must be qualified to take full charge of the broader features of motion picture engineering involved in the work under his direction.

An Active member is privileged to vote and to hold any office in the Society.

An Associate member is one who shall be not less than 18 years of age, and shall be a person who is interested in or connected with the study of motion picture technical problems or the application of them. An Associate member is not privileged to vote, to hold office or to act as chairman of any committee, although he may serve upon any committee to which he may be appointed; and, when so appointed, shall be entitled to the full voting privileges of a committee member.

A Student member is any person registered as a student, graduate or undergraduate, in a college, university, or educational institution, pursuing a course of studies in science or engineering that evidences interest in motion picture technology. Membership in this grade shall not extend more than one year beyond the termination of the student status described above. A Student member shall have the same privileges as an Associate member of the Society.

A Sustaining member is an individual, a firm, or corporation contributing substantially to the financial support of the Society.

Sec. 2.—All applications for membership or transfer, except for Honorary or Fellow membership, shall be made on blank forms provided for the purpose, and shall give a complete record of the applicant's education and experience. Honorary and Fellow membership may not be applied for.

Sec. 3.—(a) Honorary membership may be granted upon recommendation of the Board of Governors when confirmed by a four-fifths majority vote of the Honorary members, Fellows, and Active members present at any regular meeting of the Society. An Honorary member shall be exempt from all dues.

(b) Fellow membership may be granted upon recommendation of the Fellow Membership Award Committee, when confirmed by a three-fourths majority vote of the Board of Governors.

(c) Applicants for Active membership shall give as references at least one member of Active or of higher grade in good standing. Applicants shall be elected to membership by the unanimous approval of the entire membership of the appropriate Admissions Committee. In the event of a single dissenting vote or failure of any member of the Admissions Committee to vote, this application shall be referred to the Board of Governors, in which case approval of at least three-fourths of the Board of Governors shall be required.

(d) Applicants for Associate membership shall give as references one member of the Society in good standing, or two persons not members of the Society who are associated with the industry. Applicants shall be elected to membership by approval of a majority of the appropriate Admissions Committee.

(e) Applicants for Student membership shall give as reference the head of the department of the institution he is attending, this faculty member not necessarily being a member of the Society.

By-Law II

Officers

Sec. 1.—An officer or governor shall be an Honorary, a Fellow, or an Active member.

Sec. 2.—Vacancies in the Board of Governors shall be filled by the Board of Governors until the annual meeting of the Society.

By-Law III

Board of Governors

Sec. 1.—The Board of Governors shall transact the business of the Society between members' meetings, and shall meet at the call of the President, with the proviso that no meeting shall be called without at least seven (7) days' prior notice, stating the purpose of the meeting, to all members of the Board by letter or by telegram.

Sec. 2.—Nine members of the Board of Governors shall constitute a quorum at all meetings.

Sec. 3.—When voting by letter ballot, a majority affirmative vote of the total membership of the Board of Governors shall carry approval, except as otherwise provided.

Sec. 4.—The Board of Governors, when making nominations to fill vacancies in offices or on the Board, shall endeavor to nominate persons who in the aggregate are representative of the various branches or organizations of the motion picture industry to the end that there shall be no substantial predominance upon the Board, as the result of its own action, of representatives of any one or more branches or organizations of the industry.

By-Law IV

Committees

Sec. 1.—All committees, except as otherwise specified, shall be appointed by the President.

Sec. 2.—All committees shall be appointed to act for the term served by the officer who shall appoint the committees, unless their appointment is sooner terminated by the appointing officer.

Sec. 3.—Chairmen of the committees shall not be eligible to serve in such capacity for more than two consecutive terms.

Sec. 4.—Standing committees of the Society shall be as follows to be appointed as designated:

- (a) *Appointed by the President and confirmed by the Board of Governors*—
Progress Medal Award Committee
Journal Award Committee
Honorary Membership Committee
Fellow Membership Award Committee
Admissions Committees
 (Atlantic Coast Section)
 (Pacific Coast Section)
European Advisory Committee

- (b) *Appointed by the Engineering Vice-President*—
Sound Committee
Standards Committee

Studio Lighting Committee
Color Committee
Theater Engineering Committee
Exchange Practice Committee
Nontheatrical Equipment Committee
Television Committee
Test Film Quality Committee
Laboratory Practice Committee
Cinematography Committee
Process Photography Committee
Preservation of Film Committee

(c) *Appointed by the Editorial Vice-President*—

Board of Editors
Papers Committee
Progress Committee
Historical Committee
Museum Committee

(d) *Appointed by the Convention Vice-President*—

Publicity Committee
Convention Arrangements Committee
Apparatus Exhibit Committee

(e) *Appointed by the Financial Vice-President*—

Membership and Subscription Committee

Sec. 5.—Two Admissions Committees, one for the Atlantic Coast Section and one for the Pacific Coast Section, shall be appointed. The former Committee shall consist of a Chairman and six Fellow or Active members of the Society residing in the metropolitan area of New York, of whom at least four shall be members of the Board of Governors.

The latter Committee shall consist of a Chairman and four Fellow or Active members of the Society residing in the Pacific Coast area, of whom at least three shall be members of the Board of Governors.

By-Law V

Meetings

Sec. 1.—The location of each meeting of the Society shall be determined by the Board of Governors.

Sec. 2.—Only Honorary members, Fellows, and Active members shall be entitled to vote.

Sec. 3.—A quorum of the Society shall consist in number of one-fifteenth of the total number of Honorary members, Fellows, and Active members as listed in the Society's records at the close of the last fiscal year.

Sec. 4.—The fall convention shall be the annual meeting.

Sec. 5.—Special meetings may be called by the President and upon the request of any three members of the Board of Governors not including the President.

Sec. 6.—All members of the Society in any grade shall have the privilege of discussing technical material presented before the Society or its Sections.

By-Law VI***Duties of Officers***

Sec. 1.—The **President** shall preside at all business meetings of the Society and shall perform the duties pertaining to that office. As such he shall be the chief executive of the Society, to whom all other officers shall report.

Sec. 2.—In the absence of the President, the officer next in order as listed in Article IV of the Constitution shall preside at meetings and perform the duties of the President.

Sec. 3.—The five Vice-Presidents shall perform the duties separately enumerated below for each office, or as defined by the President:

(a) The **Executive Vice-President** shall represent the President in such geographical areas of the United States as shall be determined by the Board of Governors and shall be responsible for the supervision of the general affairs of the Society in such areas, as directed by the President of the Society. Should the President or Executive Vice-President remove his residence from the geographical area (Atlantic Coast or Pacific Coast) of the United States in which he resided at the time of his election, the office of Executive Vice-President shall immediately become vacant and a new Executive Vice-President elected by the Board of Governors for the unexpired portion of the term, the new Executive Vice-President to be a resident of that part of the United States from which the President or Executive Vice-President has just moved.

(b) The **Engineering Vice-President** shall appoint all technical committees. He shall be responsible for the general initiation, supervision, and coordination of the work in and among these committees. He may act as Chairman of any committee or otherwise be a member ex-officio.

(c) The **Editorial Vice-President** shall be responsible for the publication of the Society's **JOURNAL** and all other technical publications. He shall pass upon the suitability of the material for publication, and shall cause material suitable for publication to be solicited as may be needed. He shall appoint a Papers Committee and an Editorial Committee. He may act as Chairman of any committee or otherwise be a member ex-officio.

(d) The **Financial Vice-President** shall be responsible for the financial operations of the Society, and shall conduct them in accordance with budgets approved by the Board of Governors. He shall study the costs of operation and the income possibilities to the end that the greatest service may be rendered to the members of the Society within the available funds. He shall submit proposed budgets to the Board. He shall appoint at his discretion a Ways and Means Committee, a Membership Committee, a Commercial Advertising Committee, and such other committees within the scope of his work as may be needed. He may act as Chairman of any of these committees or otherwise be a member ex-officio.

(e) The **Convention Vice-President** shall be responsible for the national conventions of the Society. He shall appoint a Convention Arrangements Committee, an Apparatus Exhibit Committee, and a Publicity Committee. He may act as Chairman of any committee, or otherwise be a member ex-officio.

Sec. 4.—The **Secretary** shall keep a record of all meetings; he shall conduct the correspondence relating to his office, and shall have the care and custody of records, and the seal of the Society.

Sec. 5.—The **Treasurer** shall have charge of the funds of the Society and disburse them as and when authorized by the Financial Vice-President. He shall make an annual report, duly audited, to the Society, and a report at such other

times as may be requested. He shall be bonded in an amount to be determined by the Board of Governors and his bond filed with the Secretary.

Sec. 6.—Each officer of the Society, upon the expiration of his term of office, shall transmit to his successor a memorandum outlining the duties and policies of his office.

By-Law VII

Elections

Sec. 1.—All officers and governors shall be elected to their respective offices by a majority of ballots cast by the Active, Fellow, and Honorary members in the following manner:

Not less than three months prior to the annual fall convention, the Board of Governors shall nominate for each vacancy several suitable candidates. Nominations shall first be presented by a Nominating Committee appointed by the President, consisting of nine members, including a Chairman. The committee shall be made up of two Past-Presidents, three members of the Board of Governors not up for election, and four other Active, Fellow, or Honorary members, not currently officers or governors of the Society. Nominations shall be made by three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final unless any nominee is rejected by a three-quarters vote of the Board of Governors present and voting.

The Secretary shall then notify these candidates of their nomination. From the list of acceptances, not more than two names for each vacancy shall be selected by the Board of Governors and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the names of any Active, Fellow, or Honorary members other than those suggested by the Board of Governors may be voted for. The balloting shall then take place.

The ballot shall be enclosed in a blank envelope which is enclosed in an outer envelope bearing the Secretary's address and a space for the member's name and address. One of these shall be mailed to each Active, Fellow, and Honorary member of the Society, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes.

The sealed envelope shall be delivered by the Secretary to a Committee of Tellers appointed by the President at the annual fall convention. This committee shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly elected officers and governors of the general Society shall take office on January 1st following their election.

By-Law VIII

Dues and Indebtedness

Sec. 1.—The annual dues shall be fifteen dollars (\$15) for Fellows and Active members, seven dollars and fifty cents (\$7.50) for Associate members, and three

dollars (\$3.00) for Student members, payable on or before January 1st of each year. Current or first year's dues for new members in any calendar year shall be at the full annual rate for those notified of acceptance in the Society on or before June 30th; one-half the annual rate for those notified of acceptance in the Society on or after July 1st.

Sec. 2.—(a) Transfer of membership to a higher grade may be made at any time. If the transfer is made on or before June 30th the annual dues of the higher grade is required. If the transfer is made on or after July 1st and the member's dues for the full year has been paid, one-half of the annual dues of the higher grade is payable less one-half the annual dues of the lower grade.

(b) No credit shall be given for annual dues in a membership transfer from a higher to a lower grade, and such transfers shall take place on January 1st of each year.

(c) The Board of Governors upon their own initiative and without a transfer application may elect, by the approval of at least three-fourths of the Board, any Associate or Active member for transfer to any higher grade of membership.

Sec. 3.—Annual dues shall be paid in advance. All Honorary members, Fellows, and Active members in good standing, as defined in Section 5, may vote or otherwise participate in the meetings.

Sec. 4.—Members shall be considered delinquent whose annual dues for the year remain unpaid on February 1st. The first notice of delinquency shall be mailed February 1st. The second notice of delinquency shall be mailed, if necessary, on March 1st, and shall include a statement that the member's name will be removed from the mailing list for the JOURNAL and other publications of the Society before the mailing of the April issue of the JOURNAL. Members who are in arrears of dues on June 1st, after two notices of such delinquency have been mailed to their last address of record, shall be notified their names have been removed from the mailing list and shall be warned unless remittance is received on or before August 1st, their names shall be submitted to the Board of Governors for action at the next meeting. Back issues of the JOURNAL shall be sent, if available, to members whose dues have been paid prior to August 1st.

Sec. 5.—(a) Members whose dues remain unpaid on October 1st may be dropped from the rolls of the Society by majority vote and action of the Board, or the Board may take such action as it sees fit.

(b) Anyone who has been dropped from the rolls of the Society for nonpayment of dues shall, in the event of his application for reinstatement, be considered as a new member.

(c) Any member may be suspended or expelled for cause by a majority vote of the entire Board of Governors; provided he shall be given notice and a copy in writing of the charges preferred against him, and shall be afforded opportunity to be heard ten days prior to such action.

Sec. 6.—The provisions of Sections 1 to 4, inclusive, of this By-Law VIII given above may be modified or rescinded by action of the Board of Governors.

By-Law IX

Emblem

Sec. 1.—The emblem of the Society shall be a facsimile of a four-hole film reel with the letter *S* in the upper center opening, and the letters *M*, *P*, and *E*, in the

three lower openings, respectively. The Society's emblem may be worn by members only.

By-Law X

Publications

Sec. 1.—Papers read at meetings or submitted at other times, and all material of general interest shall be submitted to the Editorial Board, and those deemed worthy of permanent record shall be printed in the JOURNAL. A copy of each issue shall be mailed to each member in good standing to his last address of record. Extra copies of the JOURNAL shall be printed for general distribution and may be obtained from the General Office on payment of a fee fixed by the Board of Governors.

By-Law XI

Local Sections

Sec. 1.—Sections of the Society may be authorized in any state or locality where the Active, Fellow, and Honorary membership exceeds 20. The geographic boundaries of each Section shall be determined by the Board of Governors.

Upon written petition, signed by 20 or more Active members, Fellows, and Honorary members, for the authorization of a Section of the Society, the Board of Governors may grant such authorization.

Section Membership

Sec. 2.—All members of the Society of Motion Picture Engineers in good standing residing in that portion of any country set apart by the Board of Governors tributary to any local Section shall be eligible for membership in that Section, and when so enrolled they shall be entitled to all privileges that such local Section may, under the General Society's Constitution and By-Laws, provide.

Any member of the Society in good standing shall be eligible for nonresident affiliated membership of any Section under conditions and obligations prescribed for the Section. An affiliated member shall receive all notices and publications of the Section but he shall not be entitled to vote at sectional meetings.

Sec. 3.—Should the enrolled Active, Fellow, and Honorary membership of a Section fall below 20, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

Section Officers

Sec. 4.—The officers of each Section shall be a Chairman and a Secretary-Treasurer. The Section chairmen shall automatically become members of the Board of Governors of the General Society, and continue in such positions for the duration of their terms as chairmen of the local Sections. Each Section officer shall hold office for one year, or until his successor is chosen.

Section Board of Managers

Sec. 5.—The Board of Managers shall consist of the Section Chairman, the Section Past-Chairman, the Section Secretary-Treasurer, and six Active, Fellow, or

Honorary members. Each manager of a Section shall hold office for two years, or until his successor is chosen.

Section Elections

Sec. 6.—The officers and managers of a Section shall be Active, Fellow, or Honorary members of the General Society.

Not less than three months prior to the annual fall convention of the Society, nominations shall be presented to the Board of Managers of the Section by a Nominating Committee appointed by the Chairman of the Section, consisting of seven members, including a chairman. The Committee shall be composed of the present Chairman, the Past-Chairman, two other members of the Board of Managers not up for election, and three other Active, Fellow, or Honorary members of the Section not currently officers or managers of the Section. Nominations shall be made by a three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final, unless any nominee is rejected by a three-quarters vote of the Board of Managers, and in the event of such rejection the Board of Managers will make its own nomination.

The Chairman of the Section shall then notify these candidates of their nomination. From the list of acceptances, not more than two names for each vacancy shall be selected by the Board of Managers and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the names of any Active, Fellow, or Honorary members other than those suggested by the Board of Managers may be voted for. The balloting shall then take place.

The ballot shall be enclosed in a blank envelope which is enclosed in an outer envelope bearing the local Secretary-Treasurer's address and a space for the member's name and address. One of these shall be mailed to each Active, Fellow, and Honorary member of the Society residing in the geographical area covered by the Section, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary-Treasurer, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes.

The sealed envelopes shall be delivered by the Secretary-Treasurer to his Board of Managers at a duly called meeting. The Board of Managers shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly elected officers and managers shall take office on January 1st following their election.

Section Business

Sec. 7.—The business of a Section shall be conducted by the Board of Managers.

Section Expenses

Sec. 8.—(a) As early as possible in the fiscal year, the Secretary-Treasurer of each Section shall submit to the Board of Governors of the Society a budget of expenses for the year.

(b) The Treasurer of the General Society may deposit with each Section Secre-

tary-Treasurer a sum of money, the amount to be fixed by the Board of Governors, for current expenses.

(c) The Secretary-Treasurer of each Section shall send to the Treasurer of the General Society, quarterly or on demand, an itemized account of all expenditures incurred during the preceding interval.

(d) Expenses other than those enumerated in the budget, as approved by the Board of Governors of the General Society, shall not be payable from the general funds of the Society without express permission from the Board of Governors.

(e) A Section Board of Managers shall defray all expenses of the Section not provided for by the Board of Governors, from funds raised locally by donation, or fixed annual dues, or by both.

(f) The Secretary of the General Society shall, unless otherwise arranged, supply to each Section all stationery and printing necessary for the conduct of its business.

Section Meetings

Sec. 9.—The regular meetings of a Section shall be held in such places and at such hours as the Board of Managers may designate.

The Secretary-Treasurer of each Section shall forward to the Secretary of the General Society, not later than five days after a meeting of a Section, a statement of the attendance and of the business transacted.

Section Papers

Sec. 10.—Papers shall be approved by the Section's Papers Committee previously to their being presented before a Section. Manuscripts of papers presented before a Section, together with a report of the discussions and the proceedings of the Section meetings, shall be forwarded promptly by the Section Secretary-Treasurer to the Secretary of the General Society. Such material may, at the discretion of the Board of Editors of the General Society, be printed in the Society's publications.

Constitution and By-Laws

Sec. 11.—Sections shall abide by the Constitution and By-Laws of the Society and conform to the regulations of the Board of Governors. The conduct of Sections shall always be in conformity with the general policy of the Society as fixed by the Board of Governors.

By-Law XII

Amendments

Sec. 1.—These By-Laws may be amended at any regular meeting of the Society by the affirmative vote of two-thirds of the members present at a meeting who are eligible to vote thereon, a quorum being present, either on the recommendation of the Board of Governors or by a recommendation to the Board of Governors signed by any ten members of Active or higher grade, provided that the proposed amendment or amendments shall have been published in the JOURNAL of the Society, in the issue next preceding the date of the stated business meeting of the Society at which the amendment or amendments are to be acted upon.

Sec. 2.—In the event that no quorum of the voting members is present at the time of the meeting referred to in *Section 1*, the amendment or amendments shall

be referred for action to the Board of Governors. The proposed amendment or amendments then become a part of the By-Laws upon receiving the affirmative vote of three-quarters of the Board of Governors.

JOURNAL AWARD AND PROGRESS MEDAL AWARD

In accordance with the provisions of the Administrative Practices of the Society, the regulations of procedure for the Journal Award and the Progress Medal Award, a list of the names of previous recipients, and the reasons therefor, shall be published annually in the JOURNAL, as follows:

JOURNAL AWARD

The Journal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

At the fall convention of the Society a Journal Award Certificate shall be presented to the author or to each of the authors of the most outstanding paper originally published in the JOURNAL of the Society during the preceding calendar year.

Other papers published in the JOURNAL of the Society may be cited for Honorable Mention at the option of the Committee, but in any case should not exceed five in number.

The Journal Award shall be made on the basis of the following qualifications:

(1) The author, or in the event of multiple authors, at least one of the co-authors, shall be a member of the Society—(any grade). All co-authors shall receive Journal Award Certificates.

(2) The paper must deal with some technical phase of motion picture engineering.

(3) No paper given in connection with the receipt of any other Award of the Society shall be eligible.

(4) In judging of the merits of the paper, three qualities shall be considered, with the weights here indicated:

- | | |
|---|--------------|
| (a) Excellence of presentation of the material..... | 50 per cent. |
| (b) Originality and breadth of interest..... | 30 per cent. |
| (c) Technical merit and importance of material..... | 20 per cent. |

A majority vote of the entire Committee shall be required for the election to the Award. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

These regulations, a list of the names of those who have previously received the Journal Award, the year of each Award, and the titles of the papers shall be published annually in the April issue of the JOURNAL of the Society. In addition, the list of papers selected for Honorable Mention shall be published in the JOURNAL of the Society during the year current with the Award.

The Awards in previous years have been as follows:

- 1934—P. A. Snell, for his paper entitled "An Introduction to the Experimental Study of Visual Fatigue." (Published May, 1933.)
- 1935—L. A. Jones and J. H. Webb, for their paper entitled "Reciprocity Law Failure in Photographic Exposure." (Published Sept., 1934.)
- 1936—E. W. Kellogg, for his paper entitled "A Comparison of Variable-Density and Variable-Width Systems." (Published Sept., 1935.)
- 1937—D. B. Judd, for his paper entitled "Color Blindness and Anomalies of Vision." (Published June, 1936.)
- 1938—K. S. Gibson, for his paper entitled "The Analysis and Specification of Color." (Published Apr., 1937.)
- 1939—H. T. Kalmus, for his paper entitled "Technicolor Adventures in Cinemaland." (Published Dec., 1938.)
- 1940—R. R. McNath, for his paper entitled "The Surface of the Nearest Star." (Published Mar., 1939.)
- 1941—J. G. Frayne and Vincent Pagliarulo, for their paper entitled "The Effects of Ultraviolet Light on Variable-Density Recording and Printing." (Published June, 1940.)
- 1942—W. J. Albersheim and Donald MacKenzie, for their paper entitled "Analysis of Sound-Film Drives." (Published July, 1941.)
- 1943—R. R. Scoville and W. L. Bell, for their paper entitled "Design and Use of Noise-Reduction Bias Systems." (Published Feb., 1942; Award made Apr., 1944.)
- 1944—J. I. Crabtree, G. T. Eaton, and M. E. Muehler, for their paper entitled "Removal of Hypo and Silver Salts from Photographic Materials as Affected by the Composition of the Processing Solutions." (Published July, 1943.)

The present Chairman of the Journal Award Committee is F. E. Carlson.

PROGRESS MEDAL AWARD

The Progress Medal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

The Progress Medal may be awarded each year to an individual in recognition of any invention, research, or development which, in the opinion of the Committee, shall have resulted in a significant advance in the development of motion picture technology.

Any member of the Society may recommend persons deemed worthy of the Award. The recommendation in each case shall be in writing and in detail as to the accomplishments which are thought to justify consideration. The recommendation shall be seconded in writing by any two Fellows or Active members of the Society, who shall set forth their knowledge of the accomplishments of the candidate which, in their opinion, justify consideration.

A majority vote of the entire Committee shall be required to constitute an Award of the Progress Medal. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

The recipient of the Progress Medal shall be asked to present a photograph of himself to the Society and, at the discretion of the Committee, may be asked to prepare a paper for publication in the JOURNAL of the Society.

These regulations, a list of the names of those who have previously received the Medal, the year of each Award, and a statement of the reason for the Award shall be published annually in the April issue of the JOURNAL of the Society.

Previous Awards have been as follows:

The 1935 Award was made to E. C. Wente, for his work in the field of sound recording and reproduction. (Citation published Dec., 1935.)

The 1936 Award was made to C. E. K. Mees, for his work in photography. (Citation published Dec., 1936.)

The 1937 Award was made to E. W. Kellogg, for his work in the field of sound reproduction. (Citation published Dec., 1937.)

The 1938 Award was made to H. T. Kalmus, for his work in developing color motion pictures. (Citation published Dec., 1938.)

The 1939 Award was made to L. A. Jones, for his scientific researches in the field of photography. (Citation published Dec., 1939.)

The 1940 Award was made to Walt Disney, for his contributions to motion picture photography and sound recording of feature and short cartoon films. (Citation published Dec., 1940.)

The 1941 Award was made to G. L. Dimmick, for his development activities in motion picture sound recording. (Citation published Dec., 1941.)

No Awards were made in 1942 and 1943.

The 1944 Award was made to J. G. Capstaff, for his research and development of films and apparatus used in amateur cinematography. (Citation published Jan., 1945.)

The present Chairman of the Progress Medal Award Committee is E. A. Williford.

**57th SEMI-ANNUAL TECHNICAL CONFERENCE
OF THE
SOCIETY OF MOTION PICTURE ENGINEERS**

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**HOLLYWOOD-ROOSEVELT HOTEL
HOLLYWOOD, CALIFORNIA
MAY 14-18, 1945**

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Officers in Charge

D. E. HYNDMAN, *President*
HERBERT GRIFFIN, *Past-President*
L. L. RYDER, *Executive Vice-President*
J. A. MAURER, *Engineering Vice-President*
A. C. DOWNES, *Editorial Vice-President*
W. C. KUNZMANN, *Convention Vice-President*
E. A. WILLIFORD, *Secretary*
H. W. MOYSE, *Chairman, Pacific Coast Section*

« »

Directory of Committee Chairmen

Pacific Coast Section.....	H. W. MOYSE, <i>Chairman</i>
Papers Committee.....	C. R. DAILY, <i>Chairman</i> BARTON KREUZER, <i>Vice-Chairman</i>
Publicity Committee.....	E. O. BLACKBURN, <i>West Coast</i> JULIUS HABER, <i>East Coast</i>
Registration and Information.....	W. C. KUNZMANN
Reception and Local Arrangements....	EMERY HUSE
Luncheon and Dinner-Dance.....	L. L. RYDER
Hotel and Transportation.....	C. W. HANDLEY
Projection Programs—35-mm.....	R. H. McCULLOUGH, <i>Chairman, assisted by Officers and Members of I.A.T.S.E., Locals 150 and 165</i>
16-mm.....	H. W. REMERSCHEID, <i>Chairman</i>

HOTEL RESERVATIONS AND RATES

The Hollywood-Roosevelt Hotel management extends the following per diem room rates, European Plan, to SMPE members and guests attending the Fifty-Seventh Technical Conference:

Room with bath, one person.....	\$4.40
Room with bath, two persons, double bed.....	5.50
Room with bath, two persons, twin beds.....	6.60-7.70

Note: There will be no parlor suites available at the hotel during the conference dates.

Special Notice

Owing to the acute housing situation in Hollywood, the hotel management can assign the conference only a limited number of rooms for Eastern and Midwestern members attending this Conference. Therefore *no room reservation cards* will be mailed to the membership as heretofore. Accordingly, you are requested to make room reservations *direct* with Stewart H. Hathaway, Manager of the Hollywood-Roosevelt Hotel, Hollywood, California. *No rooms will be assured or guaranteed at this hotel unless confirmed by Mr. Hathaway, which are subject to cancellation prior to May 10.*

Your Conference Chairman has arranged with the Mark Hopkins Hotel management in San Francisco, California, to provide accommodations for members who will visit this city while on the West Coast. Accordingly, reservations should be made *direct* with R. E. Goldsworthy, Manager of this hotel, at least 2 weeks in advance of your arrival in San Francisco. When making reservations, advise the management that you are a member of the SMPE.

RAILROAD AND PULLMAN ACCOMMODATIONS

Eastern and Midwestern members of the Society who are contemplating attending the Conference in Hollywood should consult their local railroad passenger agent regarding train schedules, rates, stopover privileges, and Pullman accommodations at least 30 days prior to leaving, otherwise no accommodations may be available.

REGISTRATION

The Conference registration headquarters will be located on the mezzanine floor of the hotel near the Studio Lounge where all business and technical sessions will be held during the Conference. Members and guests are expected to register. The fee is used to help defray Conference expenses.

TECHNICAL PAPERS

Members and others who are contemplating the presentation of papers can greatly assist the Papers Committee in their early program assembly, and scheduling in the final program, by mailing in the title of paper, name of author, and a *complete manuscript* not later than *May 1* to the West or East Coast chairman of the Papers Committee.

CONFERENCE LUNCHEON

The usual Conference Get-Together Luncheon will be held in the Terrace Room of the hotel on Monday, May 14, at 12:30 p.m. The luncheon program will be announced later.

Members in Hollywood and vicinity will be solicited by a letter from S. P. Solow, Secretary of the Pacific Coast Section, to send remittances to him for Conference registration fee and luncheon tickets. Checks or money orders should be made payable to W. C. Kunzmann, Convention Vice-President, and not to the Society.

INFORMAL DINNER-DANCE

The Fifty-Seventh Semi-Annual Dinner-Dance and social get-together of the conference will be held in the California Room of the hotel on Wednesday evening, May 16, at 8:30 p.m.

A social hour with your Board of Governors will precede the Dinner-Dance between 7:30 p.m. and 8:30 p.m. in the Terrace Room. (Refreshments)

Table reservations may be made and tickets procured for the Dinner-Dance during the week of May 6 from W. C. Kunzmann, Convention Vice-President, Hollywood-Roosevelt Hotel, or at the registration headquarters not later than noon on *May 15*. All checks or money orders should be made payable to W. C. Kunzmann, Convention Vice-President, and not to the Society.

Because of strict food rationing and a shortage of hotel labor, your committee must know in advance of the Luncheon and Dinner-Dance the number of persons attending these functions in order to make the necessary hotel arrangements. Therefore your cooperation is solicited.

LADIES' REGISTRATION

There will be no ladies' reception committee or hostess during the Fifty-Seventh Technical Conference. However, all ladies are requested to register at the registration desk to receive identification cards for admittance to the *deluxe* motion picture theaters on Hollywood Boulevard in the vicinity of the hotel. Ladies are welcome to attend the Luncheon on May 14 and the Dinner-Dance on May 16.

MOTION PICTURES

The Fifty-Seventh Technical Conference recreational program will be announced later when arrangements have been completed by the local committee.

Conference identification cards issued only to registered members and guests will be honored through the courtesy of the following *deluxe* motion picture theaters on Hollywood Boulevard:

FOX WEST COAST GRAUMAN'S CHINESE AND EGYPTIAN
HOLLYWOOD PARAMOUNT
HOLLYWOOD PANTAGES
WARNER'S HOLLYWOOD THEATRE

*Tentative Program ***Monday, May 14, 1945**Open Morning*

- 10:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Luncheon tickets.
12:30 p.m. *Terrace Room:* SMPE Get-Together Luncheon. (Speakers)
2:00 p.m. *Studio Lounge:* Opening Conference.
Business and Technical Session.
8:00 p.m. *Studio Lounge:* Evening Session.

*Tuesday, May 15, 1945**Open Morning*

- 10:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Dinner-Dance tickets.
2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.

Wednesday, May 16, 1945

- 9:00 a.m. *Hotel Mezzanine Floor:* Registration.
Advance sale of Dinner-Dance tickets.
9:30 a.m. *Studio Lounge:* Morning Session.
Open Afternoon.

Note: Registration headquarters will be open on the afternoon of this date for those desiring to make final arrangements for Dinner-Dance tables and accommodations.
7:30 p.m. *Terrace Room:* A social hour with your Board of Governors preceding the Dinner-Dance. (Refreshments)
8:30 p.m. *California Room:* The Fifty-Seventh Semi-Annual Dinner-Dance and social get-together. Dancing and entertainment.

*Thursday, May 17, 1945**Open Morning.*

- 2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.

*Friday, May 18, 1945**Open Morning*

- 2:00 p.m. *Studio Lounge:* Afternoon Session.
8:00 p.m. *Studio Lounge:* Evening Session.
Adjournment of the Fifty-Seventh Semi-Annual Technical Conference.

* Subject to change.

IMPORTANT

The Eastern and Midwestern members who plan to attend the 1945 Spring Conference in Hollywood are again cautioned to check railroad and Pullman accommodations, and make hotel room reservations at least 30 days prior to leaving for the West Coast.

Owing to the strict food rationing and hotel labor conditions existing on the West Coast, your arrangements committee requests that Luncheon and Dinner-Dance tickets be procured prior to the dates of these functions so that accommodations can be provided accordingly.

W. C. KUNZMANN
Convention Vice-President

SOCIETY ANNOUNCEMENTS

ATLANTIC COAST SECTION MEETING

The new American War Standards 16-mm sound test films were the subject of two speakers at the meeting of the Atlantic Coast Section of the Society on February 21. Lt. Howard T. Souther of the Signal Corps Photographic Center, Long Island City, New York, reviewed the factors leading to the development of these test films, including conditions under which 16-mm projectors and equipment are operated, life of equipment, steps taken by the Signal Corps to improve conditions of operation and repair, and the final need for test films to insure optimum operation.

John A. Maurer, Engineering Vice-President of the Society, described the special equipment designed by J. A. Maurer, Inc., which is required to produce these high precision 16-mm sound test films in accordance with American War Standards. Mr. Maurer's talk was illustrated with many lantern slides showing details of the recording equipment and how the problems encountered were dealt with. The multifrequency test film was demonstrated.

These 16-mm test films are now in production and are being supplied to the Armed Forces by the Society. Details as to availability to others may be obtained by communicating with the general office.

The motion picture, *War Film Communique*, was shown to members and guests in the Salle Moderne of the Hotel Pennsylvania.

PACIFIC COAST SECTION MEETING

A presentation of the outstanding documentary film, *The Fighting Lady*, was given before members and guests of the Pacific Coast Section of the Society at a meeting held in the Paramount Studios projection room in Hollywood on February 14. Lt. Commander Robert L. Middleton, who was associated in producing the picture, discussed the problems and experiences encountered during filming and answered questions from the audience after the showing.

The dinner group preceding the meeting included Commander Middleton, E. A. Williford, Secretary, and E. I. Sponable, Governor of the Society, both visiting Hollywood, and local Section officers.

NOMINATIONS FOR ANNUAL ELECTIONS

In accordance with the Administrative Practices of the Society, a Committee on Nominations has been appointed by the President to recommend suitable candidates for offices expiring on December 31, 1945, elections for which are held prior to the October meeting. A list of these offices and the incumbents is given on the reverse of the contents page of this issue.

The Committee invites recommendations for nominations for the offices open from the voting members of the Society (Honorary, Fellow, and Active members). Names of candidates for nomination (only Honorary, Fellow, and Active members may hold office) should be submitted to the Chairman of the Committee on Nominations, whose name and address are given on page 308 of this issue, or to any committee member. A report will be submitted to the Board of Governors at their July meeting.

EMPLOYMENT SERVICE POSITIONS OPEN

Young man with several years' experience in Motion Picture Camera and Projector design. Must have mechanical background with a knowledge of motion picture industry requirements. Write or telephone for interview. Akeley Camera, Inc., 175 Varick St., New York 14, N. Y. Walker 5-7954.

Optical engineer's assistant. Acquainted with optical laboratory routine, ray tracing and similar problems in related scientific fields. Reply to Optical Engineering Department, DeVry Corporation, 1111 Armitage Ave., Chicago 14, Ill.

Position open for man or woman with experience in optical instrument design. Position also open for man or woman with experience in lens design or computing. Write for interview. Binswanger and Company, Optics Division, 645 Union Ave., Memphis, Tenn.

Physicist with special training in optics for research on utilization of carbon arcs particularly in projection systems. Apply to Research Laboratory, National Carbon Co., Inc., P. O. Box 6087, Cleveland 1, Ohio.

POSITION WANTED

Engineer desires position with manufacturer or theater circuit supervising construction, maintenance, or operation. Sixteen years' experience. For details write P. O. Box 710, Chicago, Ill.

Notices from business organizations for technical personnel and from members of the Society desiring technical positions which are received before the 15th of the month will appear in the JOURNAL of the following month. Notices should be brief and must give an address for *direct* reply. The Society reserves the right both to edit or reject any notice submitted for publication.

REPORT OF THE TREASURER

SOCIETY OF MOTION PICTURE ENGINEERS

JANUARY 1-DECEMBER 31, 1944

<i>Members' Equity, Jan. 1, 1944</i>	\$31,195.56
<i>Income, Jan.-Dec., 1944:</i>	
Membership Dues	\$15,283.36
Sustaining Memberships	5,725.00
Publications (Subscriptions, Reprints, Journals, Standards, Book, etc.)	6,845.21
Other Income (Test Films, Interest, Conferences, etc.)	8,889.44
Total	\$36,743.01
<i>Expenses, Jan.-Dec., 1944:</i>	
General Office (Salaries, Rent, Supplies, Postage, Equipment, etc.)	12,361.41
Publications (Journal, Reprints, Stand- ards, etc.)	7,401.91
Dues and Fees to Other Organizations (ASA, RTPB, NFPA, ISCC)	2,335.00
Sections (Atlantic and Pacific)	646.72
Other Expense (Committees, Awards, Test Films, Promotion, etc.)	4,337.78
Total	27,082.82
<i>Net Income, 1944</i>	9,660.19
<i>Members' Equity, Dec. 31, 1944</i>	\$40,855.75

The cash records of the Treasurer were audited for the year ended December 31, 1944, by Sparrow, Waymouth and Company, certified public accountants, and are in conformity with the above report.

M. R. BOYER,
Treasurer

JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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(The Society is not responsible for statements of authors.)

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JOURNAL

OF THE

SOCIETY of MOTION PICTURE ENGINEERS

HOTEL PENNSYLVANIA • NEW YORK 1, N.Y. • TEL. PENN. 6 0620

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*Term expires December 31, 1945. †Chairman, Pacific Coast Section.

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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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EDUCATIONAL RESEARCH IN THE PRODUCTION OF TRAINING FILMS*

HAROLD B. ROBERTS**

Summary.—*The original research problem confronting the producer of training films may be summarized as follows: (1) The isolation of the training problem demanding solution; (2) the specification of that problem in terms of trainee behavior; (3) the discovery of all factors which are expected to contribute to the solution of the behavior problem; (4) the selection of those factors which are to become the responsibility of the film; and (5) the presentation of these factors for visualization.*

The accuracy with which this problem is solved and the effectiveness with which it is presented can be the deciding factors in the development of the film as an instrument for the control of human behavior.

The Training Film Branch recognizes that its first obligation in the production of a training film is to the naval activity, ship or station, that requests the film. The nature of that obligation and the procedure for discharging it in the research stage of production are the subjects of consideration for this paper.

Requests for Navy training film production are forwarded to the Branch from a great number of naval activities. These activities undertake a wide variety of types of training and present a wide variety of training problems. For instance, the technique of making a hospital bed presents one type of problem while the teaching of motor torpedo attack tactics obviously offers quite another.

But while the hundreds of requests for production vary widely in the nature of the training involved, the assumptions on which requests are based tend to follow a fairly constant pattern. In general, the requesting agencies make the following assumptions when they ask for a training film on any given subject:

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Lieutenant, USNR, Education Specialist, Photographic Division, Training Film Branch, Bureau of Aeronautics, U. S. Navy, Washington, D. C.

- (1) A training film will speed the learning-training process.
- (2) A training film will serve as an accepted pattern of practice establishing standard procedures on all ships and stations.
- (3) A training film can be used to clarify a complicated technical problem not yet satisfactorily explained by books, charts, diagrams, or lectures.
- (4) A training film can be made so specific in nature that it will solve or assist in the solution of a single, given training problem.

The Training Film Branch, without complete knowledge of the success or failure of alternate methods of instruction, may accept those assumptions as given and the last three may constitute an outline of the obligation of the Branch to the requesting agency. The three, in fact, become primary production standards. If a film is to set standards of Navy behavior and performance, it must be technically correct and the standards universally acceptable. If a film is to clarify complicated technical problems, it must be clear, orderly, and honest. Finally, if a requesting agency is to depend on a film to solve a known and perplexing training problem, that problem must be isolated and identified. Furthermore, its solution must become a definite responsibility of the film. To produce a film that solves one or more related training problems cannot be considered sufficient. If the problem is to teach the overhaul of an engine, the film must cover more than the recognition of parts. A training problem involving the principles of ship propulsion demands a picture that is more specific than a travelogue of an engine room.

A film can fail in its obligation to the requesting agency at any number of points during production. Originally designed to attain a given objective, it may deviate from the intended course either within or between the major production stages. It appears now that the more serious variations are likely to occur between those steps which for the sake of clarity may be divided as follows: (1) the research, (2) the visualization and writing, (3) the photography and sound recording, and (4) the cutting and editing.

Success in each step is dependent first upon the effectiveness of the preceding steps and, secondly, and especially, upon the accuracy with which the accomplishments in one step are interpreted by those responsible for succeeding steps.

A heavy burden of responsibility rests with those undertaking research on the project. Research initiates the production. It establishes the relationship with the requesting authority. It must discover and identify the training problem and set in motion the procedures for solution.

The policy and procedures of the Branch to insure the fulfillment of the obligation to a requesting agency have been developed over a 30-month period. The policy is basic to the procedures and is founded upon the following assumptions:

(1) The problem of training in the Navy is to change the behavior of its trainees, officers, and men from behavior which was effective in one aspect of the handling of naval equipment and personnel to that which is effective in another. More simply, the Navy training problem is a behavior problem.

(2) For the most part, the problem involves overt, visible, measurable behavior. Navy training is related primarily to activity which can be observed easily.

(3) The training film maker is faced with the same type of problems as the training officer. The objectives of the two cannot be far apart.

(4) Any given training film, when completed, may be used in a wide variety of ways. Projection of the film may be accompanied by the best possible instruction or by none.

(5) Because the Branch cannot be sure of the conditions under which a film will be used, it must possess qualities which make it a complete, self-sufficient training instrument.

(6) Sooner or later, the hard grueling work of analyzing the training problem in terms of behavior must be done, whether at the beginning or in the middle of production. Unless the problem is defined, the purposes clarified, the desired behavior discovered, the production time will be prolonged or the picture is likely to be a poor production.

(7) Educational and psychological planning are most effectively accomplished at the beginning of production.

(8) An effective training film can be made on any subject whatsoever if the problem is definitely conceived.

On receipt of a request for a film, a 3-man team is appointed to undertake the production research. This team is composed of a Project Supervisor, an Education Officer, and a Technical Adviser. The Project Supervisor is, in effect, the Navy production manager. The Education Officer is held responsible for the educational and psychological aspects of the production. The Technical Adviser is responsible for the technical accuracy of the production from research to final editing.

The team attempts to approach the problem as simply and directly as possible. The information they seek can be indicated by a series of questions, falling roughly into 3 groups.

One group of questions seeks to discover the present general and specific relation of the trainee to the problem:

(1) What general background of knowledge does the trainee possess on this subject?

(2) What specifically does he know about the problem?

(3) How does the trainee act with regard to this subject?

(4) Which of the things he can do well are specifically related to the problem?

This group of questions is based on the age-old proposition that learning must proceed from the known to the unknown.

Another group of questions seeks to discover the nature of the present or planned training program. This group reveals the other factors which are expected to contribute to the solution of the training problem:

(1) What is the general and specific curriculum plan?

(2) Will the trainee have immediate access to the equipment?

(3) What written materials are available on the problem?

(4) What training aids in addition to the film will be available?

(5) Where in the training period will the film be used?

(6) Will the film be used by itself?

The third group of questions inquires into the nature of the required trainee behavior:

(1) What is the trainee expected to *do* or to be able to do as the result of having seen this picture? How is he expected to act?

(2) In order to be able to do the things he must do, to act the way he must act, what must he know? What information must he possess?

(3) What changes of attitude are expected to result from the film?

(4) What action is expected to result as evidence of those changes in attitude?

The answers to these 3 groups of questions are organized to form what is called a Production Outline. The Production Outline must present a thorough analysis and breakdown of the problem to be solved by the training film in terms of the *trainee* and of his *behavior* in relation to the training problem.

The function of the Production Outline in the fulfillment of the first obligation of the Training Film Branch can be stated briefly. It is, first of all, the essence of the research. As such it serves as an agreement between the Branch and the requesting agency as to the training problem to be solved. It lists the behavior changes required in trainees and it summarizes the technical points that must be taught. The kind of film that is to be produced is established by it. Carefully developed, the Production Outline becomes the first step in the production of the specific film that will fulfill the specific requirement.

The original research problem confronting the producer of training films may be summarized as follows:

- (1) The isolation of the training problem demanding solution;
- (2) The specification of that problem in terms of trainee behavior;
- (3) The discovery of all factors which are expected to contribute to the solution of the behavior problem;
- (4) The selection of those factors which are to become the responsibility of the film;
- (5) The presentation of these factors for visualization.

The accuracy with which this problem is solved and the effectiveness with which it is presented can be the deciding factors in the development of the film as an instrument for the control of human behavior.

STORY DEVELOPMENT AND CONTROL IN TRAINING FILMS*

GRANT LEENHOUTS**

Summary.—*The Navy's method of story development and control is based on a visualization of the contents of a film from the initial outline to the screening of the final composite print. Such a plan is necessary to satisfy specific Navy training requirements and to provide the right film in the least amount of time and for a minimum amount of money. Through a system of story conferences and production check points each film is developed in terms of pictures—not words. Such visualization has helped insure the success of the Navy's training film program.*

The United States Navy has a continuous training film production load averaging 1000 films, and each film is designed to fill a specific training requirement. Because of wartime urgency, a method of story development and control was established to insure the production of training films of maximum effectiveness which are produced with minimum use of time and film.

The types of training films made by the Navy can be divided into 4 broad categories: The factual "how-to-do-it" film, the "operational" type which is made under actual or simulated combat conditions, the "indoctrinal" type, and the "mental conditioning" or "attitude creating" film.

Of the 4 types of films mentioned, the first three are sometimes the easiest to produce because the Navy feels it is inadvisable to waste time and money in sugar-coating facts and fundamentals. A story woven around an intricate gunnery computer might easily confuse the basic training aspects of the film, and would certainly take longer to produce, and would cost more money. But the "mental conditioning" or "attitude creating" film not only *requires a story*, it also requires more thought and skill in production than most entertainment-type feature pictures.

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Lieutenant, USNR, Training Film Branch, Bureau of Aeronautics, U. S. Navy, Washington, D. C.

Because every Navy picture is a means to an end—answering a particular training problem—each film, no matter what the type, is designed and produced as carefully as any modern weapon. And as the weapon, the film must be aimed accurately to meet the contingencies of the Navy's vast teaching program. Whether the film is for "boots" or officers, whether it is shown in the classroom or on the hangar deck of a carrier, the film must either teach specifics or create an attitude by indirection.

Every film must stem from straight-line thinking to be right. Every film must start right and proceed without delay. There is no opportunity for expensive retakes; no time to tear scripts apart once they are written. And above all, there can be no compromise with ideas which the writers, directors, actors, editors, and cutters might want to interject during production.

The method developed by the Navy to control story development is simple and direct. Once the research is completed, the problems and objectives of the proposed film are prepared as a Production Outline by the Navy production personnel who will actually be responsible for making the picture. A conference is held among the Education Specialist, Head of the Project Supervision Section, Graphic Specialist, and members of the story planning group. They decide on the medium to be used: motion picture, slide film, black-and-white, color, 16- or 35-mm, the approximate length, the type of treatment, and the style of the training film.

Once an agreement is reached on the basic concepts and "slant" of the film, an Action Outline is prepared. This is composed of short captions denoting camera directions, and only a limited indication of narration. Narration is not stressed at this point because at this stage in production thinking is only in terms of pictures. This story-board is practically a script for a silent picture.

After this story-board, or Action Outline, is presented to the original conference group, necessary changes in drawings and camera directions are made. The dialogue or commentary is added, and a completed master script is ready for final approval and production.

This method of script control insures the production of a picture that will do the training job required of it, because it is worked out in terms of pictures, and the specialized abilities of the camera are exploited to their full extent. The problem of making the right motion picture is solved in terms of the medium of which the story will finally be presented.

The sketches in the Action Outline may be photographed as a 35-mm slide film and a recording may be made to give a complete preview of the motion picture before it is made. Music, voices, mood, tempo and over-all teaching qualities are screened and evaluated, and the story line checked and proved right or wrong.

The Navy's method of story development and control provides a simple, direct, and economical means of insuring the success of a film. By visualizing every sequence in advance, production is guided through to the final composite print with minimum use of time and money.

[A sound slide film composed of the actual story sketches and the preliminary script for a motion picture was demonstrated. This motion picture was designed to create a specific attitude in the minds of instructors who use films to train Navy men. By such presentation of a motion picture during the planning stage, unlimited opportunity is provided for objective judgment and evaluation of the ultimate effectiveness of the film.]

BLUNDERS IN TRAINING FILMS—THEIR CAUSES AND CURES*

RICHARD B. LEWIS**

Summary.—In reviewing hundreds of training films the Navy has had opportunity to isolate and to define a number of often-repeated blunders—typical weaknesses—in training films. These blunders in treatment and presentation include improper use of narration, faulty editing for training purposes, and faulty basic training film planning. Through planning procedures and through repeated checks during production these blunders can be eliminated.

Navy training film production personnel have reviewed hundreds of training films. Many of these films have been made by or for the Navy to be used in its training program. Seeing many films gives reviewers an opportunity for study, and the characteristics of effective films soon become apparent. Likewise, weaknesses in films become apparent—weaknesses which appear again and again.

I want to analyze some of the weaknesses which appear most frequently, especially in the films we usually call "nuts and bolts." Perhaps it is this very term which causes us to give too little care to the difficult job of making the "how-to-do-it" films interesting and clear. These weaknesses I want to call "blunders," for they can be avoided.

In order to avoid blunders in training films, the Navy has established production procedures with which many of you are acquainted. But, no matter how effective planning and production procedures are in theory, the war on blunders is an endless war. I feel confident in saying that real progress has been made, but occasionally a film gets to the screen filled with blunders, and few films are entirely free of them. Let us take 10 examples.

Blunder No. 1, Long Films.—We have had ample evidence from instructors who use films in their training programs that long films

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Lieutenant, USNR, Assistant Head, Training Film Branch, Bureau of Aeronautics, U. S. Navy, Washington, D. C.

are not effective. Long films usually result from an attempt to cover too much material, too many details, or from inadequate planning and organization of the film. Yet many training films, both slide films and motion pictures, are long—long and overloaded.

Navy experience seems to indicate that 20 min is the maximum length for a film for efficient utilization and effective teaching. If the subject matter is complex, a short film or a series of short films is most desirable. For example, one preliminary plan for a film on a gun used by the Navy called for 3 reels to include the duties of each member of the gun crew, the techniques used by each gun crew member in carrying out his duties, and stripping and assembling the gun. Instead of making one film, obviously too long and filled with too much detail, 3 one-reel films were made, one for each of the problems to be taught. It is unquestionable that such a series of short film units provides much more effective teaching, from the viewpoints of both instructors and students, than one long, loaded film.

The blunder of making training films too long can be eliminated in the planning stage of a training film production. The attention limits of an audience must be respected. The number of facts or principles which can be absorbed by an audience in one session must be considered. The training situation in which a film is to be used must be remembered. *Keep training films short.*

Blunder No. 2, Poor Organization.—Many films lack a plan which will insure effective teaching. Some are organized like a string of beads.* This treatment appears often in films which purport to instruct students how to run a machine or a device. One we reviewed about a year ago told how to start a complex engine. The film started with a long shot of the engine; the sound track warned the student that the task is a difficult one. The film proceeded from valve to lever to dial to lever to valve to dial to button to dial, and so on, for 20 min. This is the string of beads treatment with a flagrant eloquence. No man can remember procedures with such a presentation, even if he stays awake until the end.

Training films must be organized into clearly defined large groups of ideas, and within the large groups, smaller groups should appear. In the engine film, the grouping could have been:

* If training film writers and producers would read and apply the precepts of Harry A. Overstreet in his "Influencing Human Behavior," from which this expression was taken, they would go far in eliminating training film blunders.

Preparing for operation:

Adjusting fuel supply.

Adjusting current supply.

Safety checks before starting.

(Here a title followed by blank leader could be inserted to permit class discussion of the first steps in engine operation.)

Starting the engine:

Sub points.

(Discussion break)

Checks while running.

(Discussion break)

Securing.

(Discussion questions)

Good teaching is good thinking and the best training films have clear and simple organization which is carefully defined before any script work is started.

Blunder No. 3, Needless Narration.—Blunder 3 turns up occasionally. In one film the narration states, "A crane picks up a truck, swings it over the ship, and lowers it into the hold." On the screen the crane picks up a truck, swings it over the ship, and lowers it into the hold. This blunder is closely related to—

Blunder No. 4, Loaded Sound Tracks.—The function of the sound track is to support, explain, and clarify the picture. The sound track can explain the why's of an action, can give emphasis to an important point. A sound track loaded with talk-talk-talk is actually an obstacle to learning. Since the picture should unquestionably contribute the major teaching points in the film, the addition in the sound track of a great number of qualifying, descriptive, or technical points for each picture sequence can prevent the student from getting a clear impression from the film. Silent areas are important in the sound track of a training film. Let the audience look and think in silence; then an indispensable explanatory comment will be heard and understood. Careful study and editing of the completed script will eliminate both needless narration and loaded sound tracks from training films.

Blunder No. 5, Lecture Films.—Here is a blunder that appears in many guises: Instead of showing on the screen a new rocket, the film shows a handsome narrator sitting at an executive desk talking about the new rocket, or a lecturer, pretending to be an old and experienced rocket handler, talking about handling rockets, or a group of actors talking to each other about how effective the new rocket is said to be.

Words and personalities are substituted for pictures which are worth—or is the old Chinese proverb really backward?

This blunder of putting a lecture on film can be eliminated in what we call the Action Outline stage of script preparation when each scene of the finished film can be selected for its visual impact and training value. The development of a set of story sketches, visualizing every key sequence in the film, is an excellent method of finding where an actor talking can be removed in favor of a picture of the thing he was talking about.

In training, *things* are important far more often than personalities. And with all the possibilities of animation, stop motion, high-speed and slow-speed cameras, and so on—*things* can be dynamic! Let us avoid the lecture film.

Blunder No. 6, Missing Scenes.—This blunder is familiar. Many training films indicate clearly that the scenes to be photographed are not sufficiently planned in advance, with the result that the script does not provide for complete photographic coverage. One example, on the screen: (medium shot) hand inserting multipronged electric plug into receptacle; sound track: "The plug is inserted in the jack with the arrow on the side near the large pin toward the arrow on the jack." We cannot see the arrows, so we use 23 awkward words to tell what one close close-up would have shown better. Do not let the motto be: "If we didn't shoot it, talk about it."

Blunder No. 7, One-Angle Setups.—Close-ups and interesting and revealing camera angles are vital in training films. Camera movement should be used to the full. Sometimes special equipment is necessary and thoroughly justified by the results. One Navy film successfully demonstrates a difficult problem in benchwork on a complicated device. The viewpoint of the technician is maintained as he works on several sides of the device. To photograph the work from the technician's viewpoint, a large U-shaped track was made, upon which the camera traveled around and behind the technician as he worked. The camera recorded the work as seen by the eyes of the technician, and the audience seeing the finished picture participates in doing the job.

To illustrate further this problem of the one-angle setup, in another film the installation of an exceptionally simple but heavy piece of gear under the wing of a plane was to be shown. The script did not detail the camera angles, but simply stated opposite the written narration, "camera coverage to suit." One setup was used by the

cameraman and director, because the entire installation of the gear could be seen from one setup. A technical change in the gear necessitated reshooting, and a new director was assigned who avoided the one-setup blunder. The retakes showed the installation from 7 angles which included pictures of how the gear was picked up and lifted, how the cleats engaged the wing hooks, how the pins were inserted, how the safety-keys were installed, how the security of the attachment was tested, and how the gear appeared from side, rear, and front when installed. The screen time for both the treatments was identical, but the teaching value of the second coverage was vastly improved. Each action had received special photographic attention.

Every possible advantage must be taken of the flexibility of the camera—and the camera directions should be explained in detail in the script—or the one-angle setup blunder will be the result.

Blunder No. 8, Monotony.—This blunder applies to both picture and narration. It may seem that such a blunder as monotony is hardly possible in motion pictures, but it occurs again and again. Monotonous pace in the picture and monotonous speech in the narration are ruinous to any training value a picture might otherwise have. One memorable example is an early film on storms in which scene after scene shows beautiful rolling clouds, rolling and rolling, while the voice, in even, musical tones, drones the narration. I have attended 3 screenings of that film and have never seen all of it.

Pictures can be cut with change of pace, can be photographed with variety in visual symbols. Narration can be delivered with change of pace, change of pitch, change of voice quality. Monotony is unforgivable in any film.

Blunder No. 9, Clichés.—Over and over again, film clichés are substituted for genuine, relevant, and essential motivation material. In a film on installing gaskets, old stock shots of combat action appear like unexpected guests, presumably to justify the logic that a leaky gasket will not get a ship to the battle. There is one stock shot (credit Hollywood) in dozens of training films of a torpedo track; it has been printed right side to and wrong side to, and some day soon it will be printed upside down. It has lost its teaching punch long ago.

Sound tracks, too, suffer from clichés. I wonder how many training films end with the words "teamwork" and "final victory"?

Every training film subject has inherent visual possibilities. Slide films on geography have been interesting in design, humorous, and

powerful as teaching aids. The trite and traditional map geography transferred to the screen would represent a failure to use the potentialities of the film medium. The overhaul of diesel injectors has been presented as an interesting, easily remembered duty. And not one torpedo track is shown! Do not use clichés!

Blunder No. 10, Long Films.—But this is where I started sampling training film blunders—which we still have despite the most elaborate procedures for planning and production.

Blunders are caused by people, people who work at every stage of training film production: those who are technical advisers, project supervisors, education officers, writers, directors, cameramen, editors, and narrators. Blunders are caused by these earnest people when, during the course of production, they forget the great power and flexibility of still and motion pictures, forget the purpose of the film, or forget the audience.

Production procedures, with controls and check points, provide the opportunity for repeated evaluation of the qualities of a film as it is developed. We all, then, have but 2 things to do—first, to know blunders when we see them, and, second, to avoid them by using the production procedures and check points for the purpose for which they were intended. When we do, we will produce more films which are individual, interesting, and effective.

MACHINE BOOKKEEPING METHODS AS USED FOR NAVY TRAINING FILM PRODUCTION CONTROL*

JACK H. McCLELLAND**

Summary.—Since the number of training films in production by the Navy increased from 30 to 1800 in less than a year, it was found necessary to develop new techniques for the maintenance of adequate production control. This paper describes the punch-card type of machine bookkeeping system used by the Navy for the purpose of establishing and maintaining complete records on films in production and by means of which effective production control is exercised.

The production of audio-visual training aids by the United States Navy had its inception only a few months before the attack on Pearl Harbor, so it is still a fairly new field for specialization in the Naval Establishment. Yet, this newness has been no deterrent to that lusty growth inherent with so many activities essential to the prosecution of the war. There was in the Navy an early realization of the potentialities of motion pictures and slide films for increasing the effectiveness of teaching and for reducing the time necessary for mastery of subject matter. This eager acceptance of films for training is emphasized by the realization that one year after the basic directive was issued by the Secretary of the Navy authorizing the Bureau of Aeronautics to produce training films for the entire Navy, the Training Film Branch had over 1800 motion pictures and slide films simultaneously in production.

How to maintain close supervision over the production of all of these films immediately became a subject of vital concern. For example, military necessity demanded the earliest possible completion of films requested for combat training. Alert supervision, therefore, had to be exercised in order that potential delay of these films might be anticipated and prevented. If production facilities became jammed, it was sometimes necessary to give high-priority films the "green light" at the risk of causing some delay to other, nonoperational

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Lieutenant, USNR, Photographic Division, Training Film Branch, Bureau of Aeronautics, U. S. Navy, Washington, D. C.

types of films. Before any juggling of production schedules could be accomplished, however, dependable and easily visualized information on the exact status and background of each film in production had to be made readily available and up to date at all times. Then, too, with hundreds of films in production at commercial studios all over the country, it would have been alarmingly easy for a few to fall by the wayside. That, obviously, could not be permitted. Finally,



FIG. 1. Punch cards used by Navy to record production information concerning one typical film.

there has always been a definite shortage of trained supervisory personnel necessitating close observation of the work-load of each available supervisor and frequent adjustment of project assignments in order that talents and time may be completely utilized. With these preliminary evidences of the need for adequate methods of production control, officers of the Training Film Branch began to explore various possible solutions.

Several manual approaches to the problem of maintaining production records were tried and found wanting in one or more respects. Finally, it was decided that the punch-card method used in many

machine bookkeeping processes for handling large volumes of minute detail might be used to advantage in this situation. With that in view, research was instituted to determine what features the ideal system must have in order to satisfy all current and possible future needs. The requirements thus formulated were as follows:

- (1) A way of recording current production activity or status of each project as well as its recent production history is essential;



FIG. 2. Converting data furnished by Training Film Branch into punch-card form.

- (2) Administrative personnel should have constantly at their finger-tips complete records on the proposed production schedule for each project;
- (3) There should be a convenient way for comparing each film's current production activity with its scheduled activity in order that any tendency to fall behind schedule may be quickly noticed;
- (4) Both serial number and title should be given at all times as an aid to positive identification;
- (5) There should be some means of identifying the requesting authority for each film. It would be helpful to furnish each requesting authority with a periodic statement of the status of all films being prepared for that authority;
- (6) The project supervisor responsible for each film should be easily identified from the records. It would also be helpful to be able to assemble each super-

visor's films into a single list frequently in order that his production load and production problems may be analyzed;

(7) The producer selected for each project should be easily identified from the records and provision made for the segregation of all films being made by any given producer in order to permit an analysis of that producer's work-load and other problems;

(8) There must be an indication of priority of each film;

(9) As a concise indication of production span, provision should be made for the listing of the date upon which the Training Film Branch assumed responsibility for the film along with the date when delivery of prints is guaranteed by the producer;



FIG. 3. Sequencing punch cards on the sorting machine.

(10) The security classification for each film should be clearly evident at all times with minimum opportunities for error;

(11) Since information concerning the use of color, width of film being used, and length are all intimately related to the problems of scheduling both production and laboratory facilities, these factors should be noted in any set of records to be used for production control;

(12) The causes for any delay that may arise should be readily ascertainable;

(13) Since the project supervisor is the officer responsible for the film and is most closely associated with it, there would be distinct advantages to having him keep the records for his films up to date. If that can be arranged, the supervisor would, of course, prefer records requiring a minimum of detail work for maintenance;

(14) The system finally adopted should be one capable of unlimited expansion to allow for variations in the production load;

(15) All of the above information should be accurately listed in readily available form to permit quick response to each of the many daily requests for specific production information.

Those were the prime requisites of any scheme devised for use by the Training Film Branch in the exercising of effective control over training film production. There remained only the overwhelming task of figuring out how each of these requirements might be satisfied

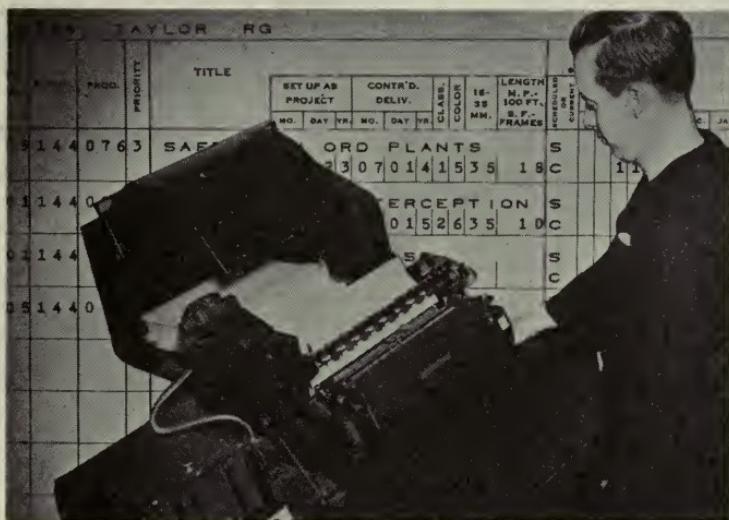


FIG. 4. Printing tabulator translating punch-card data into printed form.

and then welding their various solutions into a simple but trustworthy framework.

Such a framework was developed. Before discussing details of its operation, however, it will be necessary to acquire at least a nodding acquaintance with the 2 fundamentals serving as a basis for the whole system. Those fundamentals are:

- (1) The components and possibilities of a punch-card machine bookkeeping system;
- (2) Production procedures, routines, and terminology developed by officers in the Bureau of Aeronautics.

Both fundamentals will be described but briefly, for punch-card machine bookkeeping systems are used in many business installations

where large volumes of bookkeeping detail are handled, and Navy production procedures were described in a paper¹ read before this Society by Lieutenant R. B. Lewis at the October 1943 Conference in Hollywood and subsequently published in the JOURNAL for February 1944.

(1) Components and Possibilities of an Elementary Machine Bookkeeping System.—The punch-card system used by the Navy Training Film Branch for keeping records mechanically utilizes

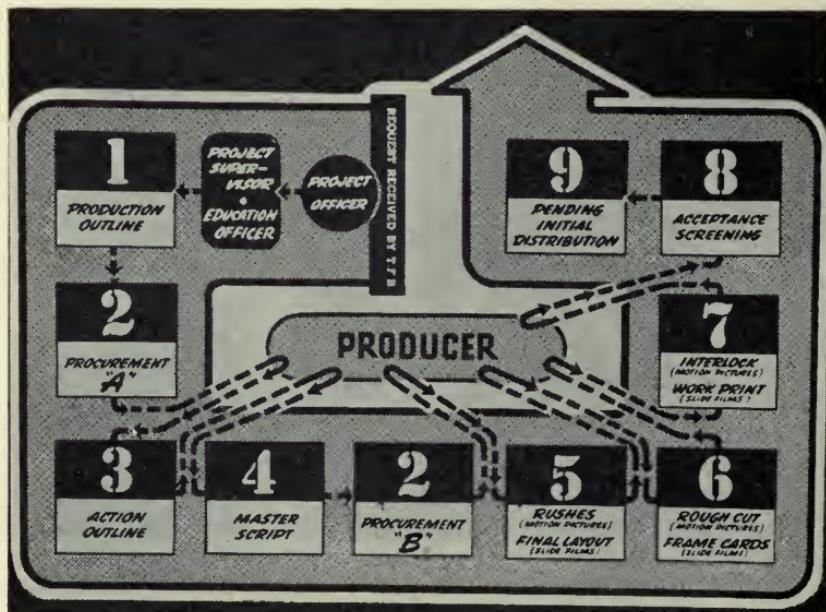


FIG. 5. Stages of production for both motion pictures and slide films produced by the Navy Training Film Branch.

cards $7\frac{3}{8} \times 3\frac{1}{4}$ in. in size on which to record any desired information. The cards are coded as shown in Fig. 1 by means of holes punched in the cards—the position of the hole or holes in each of the 80 columns determining the character so recorded in that column. It is therefore possible to record 80 characters on any one card. The cards shown in Fig. 1 are a typical pair representing information about one film. It will be noted that the cards have been “interpreted” in this sample. That is, information recorded by means of holes punched in the body of the card has been translated back into printed symbols along the top of each card.

In Fig. 2, punch-card operators are punching data furnished by the Training Film Branch into the cards. These cards, then, become the permanent record and the information they contain may be reproduced at any time.

The cards alone would not be particularly helpful if it were necessary to sort them by hand every time it was desired to change their sequence. So, the sorting machine pictured in Fig. 3 has been made available. By means of that unit, a deck of cards may be sorted into any desired sequence or grouping. For instance, suppose there is

FIG. 6. Training Film Status Report form used for production control.

occasion to segregate from an assorted deck all cards having the numeral 7 punched in the fifteenth column. A simple adjustment of a small electrical contact or brush on the machine enables the operator to feed a large stack of cards into the right end of the machine and have all cards with the numeral 7 in the fifteenth column drop into the seventh pocket. By an extension of this idea, such a machine may be used for putting cards into numerical sequence, alphabetical sequence or for any other special grouping.

Finally, there is shown in Fig. 4 the so-called printing tabulator by means of which holes punched in the cards are translated back into printed symbols. It is a highly versatile piece of equipment—so

much so that many of its summarizing, calculating, and other features are almost uncanny. As far as an understanding of training film production control procedures is concerned, however, it is only necessary to know that it is a machine which scans the holes punched in a card and then prints the symbols so recorded onto any appropriate sheet of paper.

(2) **Production Procedures.**—Officers in the Training Film Branch have established a production framework equally applicable to both motion pictures and slide films. The stages numbered in

SERIAL NO.	REQ. AUTH.	SUPVR.	PROD.	PRIORITY	TITLE
MN 1921C	091440763				

FIG. 7. Section of Status Report showing data under "Serial No.," "Requesting Authority," "Project Supervisor," "Producer," and "Priority Rating."

Fig. 5 have been standardized to such an extent that there are but few occasions when films do not naturally fall into the pattern. As far as the Training Film Branch is concerned, the first 3 stages of production in making a picture may be considered analogous to corresponding stages in the building of a house. The Production Outline, for instance, is the outline of requirements and specifications, or—to pursue the house building analogy—the Production Outline corresponds to the architect's notes regarding what features the house must include. These are established, of course, through conferences with the prospective owner or requesting authority. Similarly, the Action Outline has its counterpart in the architect's

perspective sketch while the Master Script corresponds to the architect's final, detailed blueprint.

Subsequent stages of production do not deviate particularly from procedures and terminology employed in standard production practice. It need only be said further that each stage of production is in fact a definite stage with sharply defined limits. Hence, if it is reported that project *MN-2993* is in status 7, we know that the rough cut has been approved and that the interlock screening is the next production milepost.

TITLE	SET UP AS			CONTR'D.			CLASS.	COLOR	LENGTH			
	PROJECT			DELIV.								
	MO.	DAY	YR.	MO.	DAY	YR.						
SAFETY IN ORD PLANTS												
	09	12	31	20	14	18	35		18			

FIG. 8. Status Report showing abbreviated title, date request was approved, producer's delivery date, and other pertinent data.

THE TRAINING FILM STATUS REPORT

The Training Film Status Report form used for production control in the Navy's training film program is shown in Fig. 6 as it is received by the project supervisor twice each month. This form is filled in by the machine pictured in Fig. 4 from the cards previously described. It will be noted that each listing requires 2 lines of 80 figures and letters, each extending across the entire width of the page. Since one card has a capacity of just 80 characters, it follows that 2 cards are required fully to record all information needed on each film.

Going to Fig. 7, it is easier to see what information is recorded. For example, project *MN-1921C* was requested by requesting author-

ity number 9. The Executive Office of the Secretary of the Navy happens to be number 9 in the list of requesting authorities. Other offices and bureaus empowered to approve requests for the production of training films are similarly identified by code numbers.

It is further recorded here that officer supervisor number 144, Lieutenant Taylor, is the film's project supervisor. Producer number 76 was selected to produce this film which has a priority rating of 3.

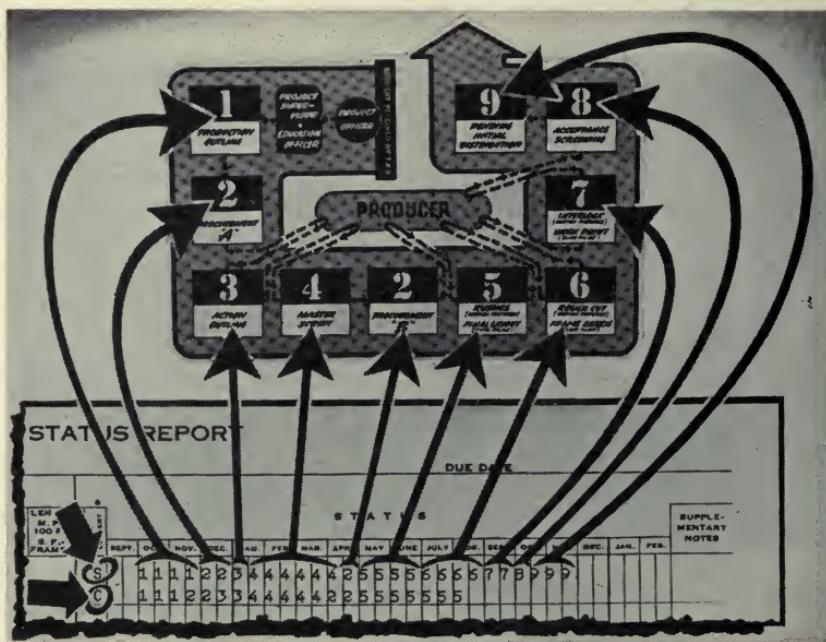


FIG. 9. Detail of specific status figures.

The adjacent area of the Training Film Status Report form as shown in Fig. 8 gives, in the first line, an abbreviated version of the title to clinch the identification. The second line shows that the approved letter of request for production was received by the Training Film Branch on September 12, 1943, and that according to the producer's contract approval prints must be delivered to the Navy not later than December 1, 1944. Adjacent columns show that the film is "nonclassified" (code number 1), that it is being shot in 35-mm black-and-white, and that the anticipated completed length is 1800 ft.

The indication of status, both scheduled and current, is shown in Fig. 9. For the sake of clarity, each status figure has been identified with that stage of production on the production procedure chart which it represents. It is to be noted that the first row of figures shows the production schedule as established near the start of work on the film by the project supervisor, in conference with the producer selected to do the job, while the actual status of the film at any time up to the present report is given by the second row of figures for each listing.

MOTION PICTURES		1	1	1					3	4
SLIDE FILMS										
STATUS	1	2	3	4	5	6	7	8	9	TOTALS
										GRAND TOTALS
PRODUCTION SUMMARY										

FIG. 10. Production summary supplying quick analysis of status of any group of films.

If the film is on schedule, the "Scheduled" and "Current" status figures for the given reporting period will be identical. Any deviation will be explained by a code figure appearing in the column headed "Supplementary Notes." For instance, if the figure 81 had been inserted in this column, it would have indicated that bad weather was causing the delay. Detailed information concerning the background of the delay must be submitted on a separate sheet of paper for filing with the permanent case history of the film.

In Fig. 10 may be seen that feature of the Training Film Status Report which permits a quick analysis of the status of any group of

films. Tabulations are made automatically during printing and show in this case, that Lieutenant Taylor has one motion picture in each of the 3 production stages identified as 3, 4, and 5. In the "Totals" column, it shows that he has 3 motion pictures and no slide films in work. This is further totaled in the "Grand Totals" column to show that he has 4 films assigned to him for production but that only 3 are in work. This summary becomes much more significant where larger lists of films are involved, as is usually the case. Furthermore, it is not limited just to the activity of the supervisor. For instance, a bi-

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FIG. 11. Project supervisor's biweekly check-off list.

weekly list is prepared grouping all films according to producer. Thus, a tabulation is always available regarding the state of each producer's work-load for the Navy.

Paralleling any system for record keeping must be a smooth working plan for keeping those records up to date. To this end, the check-off list shown in Fig. 11 has been furnished each project supervisor. Since he is the one responsible for the progress of all films assigned to him, it is his responsibility to see that records concerning his films are brought up to date twice each month. On the first and twentieth of the month, he receives 2 copies of a Training Film Status Report sheet listing all films for which he is held responsible. He immediately:

- (1) Verifies the accuracy of data listed about each of his films;
- (2) Enters a status code figure in the space reserved for the current reporting period for each film;
- (3) Enters code figures in the "Supplementary Notes" column to explain delays. Each such explanatory code figure must be accompanied by a detailed written report explaining the background of the delay. The report form used is also shown in Fig. 11;
- (4) Signs the sheet, dates it and indicates mailing address to which the next report should be sent;



FIG. 12. Cycle of operation for maintenance procedures.

- (5) Mails one copy of the amended report to the Washington Office of the Training Film Branch, Cataloging Section. (The second copy is for him to retain for his own use.)

Since these reports are circulated twice each month, it means that closely coordinated maintenance procedures are an absolute necessity. The cycle of operation is shown in Fig. 12. In operation, 10 days are allowed for the project supervisor to receive the Status Report through the mail, bring it up to date and have it back in Washington by the deadline. With mails delayed as they frequently may be in time of war, that sometimes becomes an uncomfortably tight schedule. The remaining 5 days in each cycle are devoted to bringing the punch cards up to date in accordance with entries made on the Status Report

by the project supervisor and to the printing of a new Status Report list.

Fig. 13 shows how status figures entered by hand compare with those same entries printed by machine for the next Status Report.

Finally, all films in production are grouped in several different ways at the time the biweekly statement is prepared. For instance, every title will appear in each of the following lists:

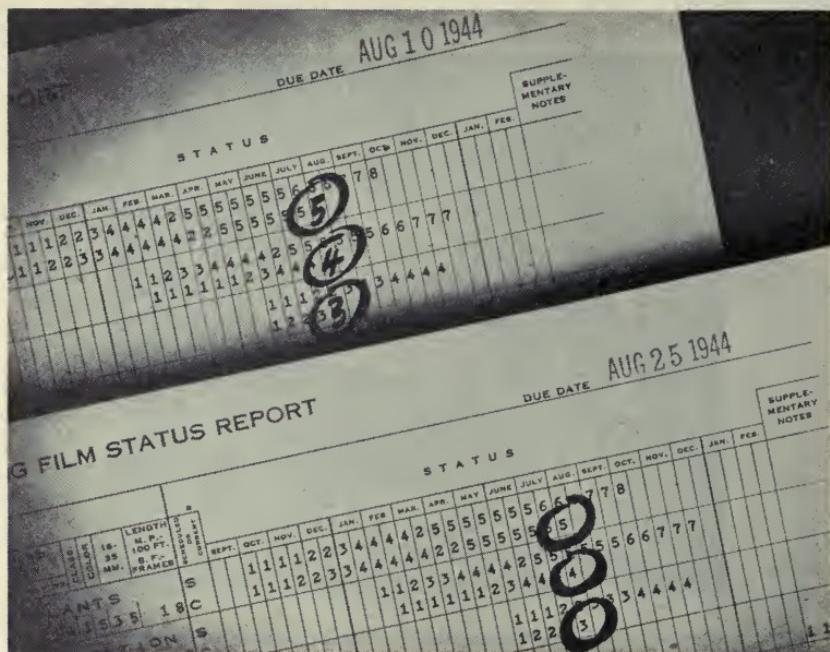


FIG. 13. Status figures entered by hand by project supervisor are machine-printed on next report.

- (1) In serial number sequence;
 - (2) Grouped according to requesting authority;
 - (3) Grouped according to project supervisor;
 - (4) Grouped according to producer.

It is with these special lists that administrative personnel are able to analyze recurrent production problems and accomplish effective production control. For ease of reference, they are bound as shown in Fig. 14.

Thus, the exacting requirements set down for a production control system have been met in virtually every respect. All essential

information is recorded in an easily interpreted form and may be reproduced mechanically in any order and at great speed without fear of the typographical errors inherent in a manually prepared list. It is easy to maintain—both for the project supervisor and the Washington office—and any difficulty encountered by a supervisor or

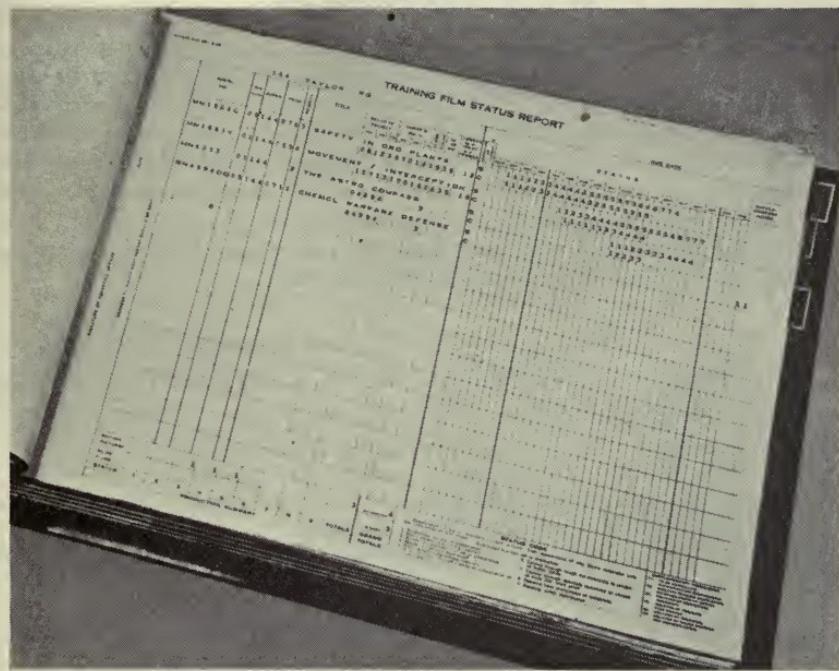


FIG. 14. Bound file of Training Film Status Reports.

producer causing the film to fall behind schedule is readily detected. And finally, expansion is achieved by the simple expedient of adding more cards to the deck so, for all practical purposes, there is no limit to the production load that can be handled smoothly and efficiently.

REFERENCE

¹ LEWIS, R. B.: "Production Planning for Navy Training Films," *J. Soc. Mot. Pict. Eng.*, 42, 2 (Feb., 1944), p. 78.

THE GUN CAMERA*

R. S. QUACKENBUSH, JR.**

Summary.—*The primary purpose of the gun camera presently used in Navy planes is to improve the efficiency of the pilots and gunners. Although formerly used exclusively for fixed or free gunnery training in slow-speed planes firing no ordnance, it now has 3 basic uses: (1) basic training in free and fixed gunnery, (2) advance training in free and fixed gunnery, (3) combat recording of our own machine gun or cannon fire on enemy ships, planes, and installations.*

This paper describes the problems peculiar to gun camera photography such as clearness and sharpness, use of color film, and vibration.

The primary purpose of the gun camera presently used in Navy planes is to improve the efficiency of the pilots and gunners. Although formerly used exclusively for fixed or free gunnery training in slow-speed planes firing no ordnance, it now has 3 basic uses:

- (1) Basic training in free and fixed gunnery.
- (2) Advanced training in free and fixed gunnery.
- (3) Combat recording of our own machine gun or cannon fire on enemy ships, planes, and installations.

In each of the above uses, our first concern must be to have a gun camera that will secure pictures which will give our men valuable, accurate information to help them improve their efficiency in combat.

As basic training in fixed and free gunnery is a vital phase of the climb to efficiency and effectiveness of every pilot and gunner, the use of the gun camera in basic training is of great importance. The problems encountered in basic training planes, however, present few problems which the camera does not overcome consistently. Vibration of the camera and speed of the plane is no great problem as most cameras are installed in the cockpit and no machine guns are fired. It is obvious, therefore, that if the camera can be made to satisfy combat conditions, it can meet any problems which may arise during basic

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Commander, USN, Director of Photography, Navy Department, Washington, D. C.

training. This conclusion applies equally to cameras used for advance gunnery training. In this phase of the camera's use, simulated combat techniques and live ammunition are used.

The present gun camera used in Navy planes is a far cry from the gun camera used in 1928. From a hand-wind camera, operating at 12 or 16 frames per sec, and installed in a simulated machine gun, it has evolved into an electrically driven camera operating at 16, 32, or 64 frames per sec and which is installed in many types of planes and in a variety of locations. The camera is a special 16-mm magazine loading unit designed for taking motion pictures from an airplane while in flight. Its mechanism is driven by a 24-v d-c motor mounted within the camera housing. The lens has 35-mm focal length and relative aperture of $f/3.5$ and is equipped with a removable filter. A manually set dial allows preselection of any of the 3 operating speeds of 16, 32, or 64 frames per sec. A manually set footage dial shows the amount of film remaining in the magazine. Its physical dimensions are approximately $6 \times 3\frac{1}{4} \times 2\frac{1}{2}$ in., with a weight unloaded of 2.75 lb. The magazine contains 50 ft of film.

Combat recording is the phase of gun camera photography which has taxed the ability of the gun camera to obtain clear and sharp pictures. The conditions met in combat areas which must be overcome are:

- (1) High plane speeds encountered under the following conditions:
 - (a) Dive bombing.
 - (b) Torpedo bombing.
 - (c) Strafing missions.
 - (d) Air-to-air combat.
- (2) Vibration.
- (3) Adverse weather conditions.

Dive bombing, torpedo bombing, and strafing missions create problems for the gun camera, but it is in air-to-air combat that the gun camera is put to its greatest test, therefore the discussion below will be confined to this subject alone.

The relative speeds of planes in air-to-air combat vary from very low to very high and from close-in fighting to long-range combat. If we assume that vibration problems are eliminated from this discussion, the question of plane speed can be more clearly seen. The principle of image motion in photography is no problem for the present gun camera *provided* the relative speed of the pursuing plane to the plane under attack is low. In other words, if the 2 planes are travel-

ing at the same rate of speed and in the same direction, the shutter speed can be low and no blurriness or motion will be discernible in the picture. As the opponent's direction and relative speed increases, however, the need grows for a higher shutter speed. If we assume that an enemy plane, traveling at 350 mph, flashes across the pursuing pilot's line of flight at right angles so the pilot is forced to do full deflection shooting, the enemy plane would have to be in excess of 1060 ft distant if the maximum speed of 64 frames per sec of the present camera is to obtain clear pictures. As conditions may and often do develop in combat which are in excess of those cited above, it is necessary that the camera be able to meet them. At present it does not, hence the need for a higher effective shutter speed for the gun camera.

There exist 2 ways to increase the effective shutter speed of the gun camera. One method which increases the effective shutter speed is to increase the speed above 64 frames per sec. This method is not practical for several reasons. The speeds at which gun cameras operate are controlled by gears, consequently to increase the frames per sec speed would entail the installation of higher speed gears in all cameras in the Navy. This can be done, but it is not practical. If it is assumed that the camera speed could be increased to 72, 80, 90, or 96 frames per sec it, too, would not be practical. The maximum capacity of the film magazine is 50 ft. At 64 frames per sec, the 50 ft of film will last only an absolute maximum of $31\frac{1}{4}$ sec of operation. At an assumed rate of fire of 11 rounds of ammunition per sec and 400 lb of ammunition per machine gun, the ammunition magazine will expend its entire load in 36.3 sec. Although this exceeds the maximum film supply by over 5 sec, it is usually sufficient. Our planes in air-to-air combat seldom expend their full load of ammunition before shooting enemy planes down. It is not desirable, however, to further decrease the relative film supply by speeding up the consumption of film. In addition to the above, the film magazines are not designed to operate at higher speeds. As many men who have handled gun cameras and film in the field know, the problem of securing satisfactory results at 64 frames per sec requires constant vigilance. To increase the speed would only produce an excessive number of magazine jams.

The desirable method of increasing the effective shutter speed of the camera is to decrease the diaphragm opening of the shutter. The present camera is equipped with a 128-degree shutter opening. The effective shutter speeds obtained with the present camera are as follows:

Frames per Second	Effective Shutter Speed
16	$\frac{1}{45}$ sec
32	$\frac{1}{90}$ sec
64	$\frac{1}{180}$ sec

To increase the present shutter speed, the diaphragm opening of the shutter can be decreased in size. The effective shutter speeds increase as follows: from a shutter opening of 128 degrees an effective shutter speed of $\frac{1}{45}$ sec is obtained when the camera is operated at 16 frames per sec; at a shutter opening of 30 degrees we obtain an effective shutter speed of $\frac{1}{768}$ sec with the camera operating at 64 frames per sec. Shutter openings between these 2 positions will give proportionate effective shutter speeds corresponding to the rate taking the photographs.

If the camera shutter is reduced to the smallest opening commensurate with the highest speed film available for gun camera use, it is obvious that it will be possible to obtain much sharper and clearer pictures than can be secured using the present 128-degree shutter opening. On the basis of tests made under combat conditions in the South Pacific area for a period of over 4 months, it was determined that a shutter having a 45-degree opening when used in conjunction with a film of Weston speed 80, exposure index 100, was satisfactory for use under practically all kinds of adverse weather conditions which still permitted planes to fly on combat missions. Intermittent motion encountered by the use of the 45-degree shutter was not generally objectionable when viewed at 24 frames per sec, the standard motion picture projection speed.

The use of 64 frames per sec is not mandatory by any means, but as it produces the most desirable results it was used in the foregoing discussion. It is obvious that a camera operating at 64 frames per sec will produce double the number of pictures obtained by one operating at 32 frames per sec, but the desirability of using this higher speed has not been clearly understood by many who have used the camera. Since a sound projector operates at 24 frames per sec, pictures taken at 64 frames per sec are projected at this slower speed, and consequently the result is actually a slow-motion effect. Where this effect is used on a ground object moving slowly, this effect is of little value except for humorous purposes. When the effect is applied to film of air-to-air combat, strafing, or bombing, however, the techniques of pilots can be examined, studied and valuable information obtained. The value of this type of study is not limited to the pilot alone. In-

telligence officers can obtain valuable information from scenes of enemy planes and target areas.

In the past, owing to problems which arose as a result of the war, various types of films were used in gun cameras. This caused much difficulty in processing in the field. However, a standard black-and-white film either reversible or negative is now obtainable using standard processing formulas. In addition, Kodachrome is also employed. Kodachrome film has great value in its ability to render scenes in their relatively true color, a quality which cannot be underestimated. It permits the observer to view in vivid color, scenes obtained under combat conditions. Planes shot down in combat blaze a brilliant red. Ships explode and their denouement is awesome and breathtakingly spectacular. The scenes of action and battle are portrayed in a manner which must be seen to be appreciated. It is a fact that Kodachrome provides a medium by which the observer is transported to the scene of battle and feels himself a part of the action. Kodachrome is indeed very high in publicity value, and this is no small phase of the war.

The disadvantages of Kodachrome in gun cameras, unfortunately, are numerous. As Kodachrome cannot be satisfactorily processed in the field, it must of necessity be at least several days after it is exposed in combat before it can be seen by the pilots who obtained it, hence its value to them progressively decreases as the lapse of time between exposure and projection increases. This problem, too, eliminates whatever intelligence value the film might have had to the briefing officers directly concerned with viewing films of enemy planes, ships, or installations while on task force missions.

Kodachrome, although factory loaded, jams at times in the magazines in an excessively high percentage of instances when the cameras operate at 64 frames per sec; consequently 32 frames per sec is the desirable and usual operating speed of the camera. It can only be used satisfactorily, even at 32 frames per sec, on clear bright days when light values are high. When 64 frames per sec shutter speed is used, results are generally unsatisfactory owing to underexposure—and this is true with the existing 128-degree shutter.

The keeping qualities of film under the adverse weather conditions encountered in the Fleet create problems which make its use uncertain, and which require highly trained personnel to handle it effectively. The use of Kodachrome film at 32 frames per sec with a standard 128-degree shutter cannot possibly produce the clarity and

detail in gun camera pictures obtainable by using a high-speed panchromatic film, 64 frames per sec, and a 45-degree shutter.

It can be stated that color film will produce spectacular combat scenes which are invaluable for publicity purposes. Experiments are being conducted with Ansco Color Film and Aero Kodacolor film cut to 16-mm widths, both of which appear to be satisfactory and may be processed in the field. It is expected that the use of these 3-color films will give best all-around results.

In processing black-and-white films various methods are employed. The most satisfactory method is the use of the Houston continuous processing machines which control temperatures to a limited degree. These machines come in 3 different sizes and are capable of duplicating the film to either a positive or negative. Other methods are the employment of Steinman tanks which are a series of small tanks having a spiral container, or the use of racks with deep tanks. Details of the processing are discussed in a paper prepared by Lt. Comdr. L. M. Dearing.¹

Vibration, the second major problem preventing good gun camera pictures, is one which should be under effective control. Special shock mounts overcome major vibration problems. It should be pointed out that these mounts do not eliminate vibration. They do, however, reduce it considerably. Although not directly related to the problem of vibration, the use of a camera with a 45-degree shutter in conjunction with special mounts will further tend to reduce the effect of vibration, hence both are desirable features in improving the photographic results of the gun camera.

The problem of adverse weather conditions, so far as they affect the photographic results of the gun camera, will be overcome to a marked degree by the use of lens heaters of a type now being tested. When these are universally used, the adverse weather problem will be greatly reduced if not eliminated. An internal automatic heating device maintains proper temperatures in the camera when the temperatures are below freezing.

The installation of the camera is a major factor in obtaining satisfactory photographic results from gun cameras. This consists of 2 problems:

- (1) The camera location.
- (2) The camera operation.

The subject of the camera location can be divided into 2 classifications as follows:

- (1) Cockpit or fuselage installations.
- (2) Wing installations.

Cockpit and fuselage installations of gun cameras are usually found in training planes, which operate at much slower speeds than combat planes. In these locations, the pictures are secured through the sweep of the propeller. This location of the camera is desirable because more accurate evaluation of training film is possible from this location. It is not, however, a desirable installation from the point of view of the combat pilot. Obviously, his first consideration is to perform his mission and return safely. To accomplish this all-important consideration, he is not very willing to lose any visions of his enemy or his target as a result of a camera installation. It is obvious, therefore, that a more desirable location for the gun camera is one which does not interfere with the combat pilot's vision.

The leading edge of the wing is the next most desirable location and most of our combat planes are so equipped. If a camera placed in the leading edge of the wing can be installed *outside* the sweep of the propeller, this is highly desirable. When a camera is located within the sweep of the propeller and operated at high speed, the propeller causes a stroboscopic effect which is objectionable.

If the camera is in a wing installation, outside the sweep of the propeller, the greatest obstacle to satisfactory results is removed. There is, however, another feature of the wing installation which is important—the manner in which the camera lens takes pictures. In some model planes, the camera lens is out in the open. In others, however, the camera lens is behind a curved window which produces distortion. Dirt, oil, and scratches on the windows further reduce the effectiveness of the camera. Improved installations and proper maintenance are improving these conditions.

The cameras operate through the machine gun or trigger button on the stick. A control is contained within the camera mechanism which permits the camera to take pictures for a variable period, as selected, from one to 5 sec after the machine gun has ceased to operate. This permits conclusive photographs of the results of the firing of the guns. This is known as an overrun control. In fighter planes, this is the only desirable method of operation. On dive-bombing aircraft, however, the camera's operation provides for continuous operation during the course of a dive-bombing run.

CONCLUSION

From a relatively crude device used in training, the gun camera has become a highly refined instrument which is used throughout air fighters' training and in combat action. It is of tremendous importance in improving our effectiveness in the war in the air.

REFERENCE

- ¹ DEARING, L. M.: "Fleet Processing of 16-mm Gun Camera and Combat Films," *J. Soc. Mot. Pict. Eng.*, 44, 4 (Apr., 1945), p. 231.

DEVELOPMENTS IN ARMY AIR FORCES TRAINING FILMS*

HOWARD A. GRAY**

Summary.—The training films mentioned in this paper were prepared by the 18th AAF Base Unit, Culver City, Calif. For purposes of clarification, training films are defined as sound motion pictures prepared for formal instructional purposes and treating specific units of subject matter. Examples are given of films dealing with matters of military intelligence, ordnance and bombing problems, and recognition of aircraft and ground vehicles.

While it is anticipated that the number of training film projects of the AAF will decrease as the war enters its final stages, it is apparent that many new training films will be required in the post-war days.

A report on the general development, distribution, and use of training films by the Army Air Forces was presented to the October 1943 meeting of this Society.¹ This paper will describe advances made in the production of training films during the past year.

For purposes of clarification, training films are defined as sound motion pictures prepared for formal instructional purposes and treating specific units of subject matter. Such films are to be distinguished from other types of motion pictures such as documentary, orientation, and operational films.

The training films mentioned in this paper were prepared by the 18th AAF Base Unit, Culver City, California, formerly known as the AAF First Motion Picture Unit. This organization is made up of personnel largely recruited from the motion picture industry and the contributions of this group to the preparation of training films is signal.

The adage that experience is the best teacher has been borne out in the development of training films for the Air Forces. Experience coming from combat operations have made necessary the revision of training programs and materials of instruction to clarify the new concepts gained.

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Major, AC, Assistant Chief of Air Staff, Training Aids Division, New York.

For example, in 1938 the German General Von Fritsch said, "The military organization with the best photographic reconnaissance will win the next war." The validity of this statement was attested by developments in both the European and Pacific war theaters and the need arose for skilled personnel to interpret aerial photographs in planning and assessing military operations. To meet this requirement, *TF 1-870, Photographic Interpretation Technique*, was produced. This picture portrays advantages of vertical-angle shots taken from high or low oblique angles and how stereo-vision aids in bringing out the detail so vital to military operations. The smooth, light-reflecting surfaces of paved highways are contrasted to the duller appearance of dirt and gravel roads. The film also depicts characteristics of swampy areas and marshes, bushlands and forests, plowed lands, meadows, and grasslands. The appearance of camouflage devices commonly resorted to by the enemy likewise are shown.

As companion pictures to this film, *TF 1-3306, Photographic Intelligence for Bombardment Aviation*, and *TF 1-3340, Photographic Intelligence and Damage Assessment*, show applications of photographic interpretation techniques to common bombing and operational problems.

Other matters of military intelligence, resulting in problems for intelligence training, had been solved by means of motion pictures. *TF 1-3383, Resisting Enemy Interrogation*, describes methods employed by German intelligence officers in interrogating captured American aircrews. The film emphasizes the need for revealing, when captured, only the name, rank, and serial number of the individual and describes the rights of prisoners of war under International Law. The trickery resorted to by the enemy in securing information of military value from unsuspected prisoners is so dramatized as to provide an unforgettable lesson.

Another film of this type, *TF 1-3326, Interrogation of Enemy Airmen*, was produced to train intelligence officers in the art of questioning German, Italian, and Japanese prisoners. The importance of knowing about the customs, habits, and psychology of each nationality is demonstrated. The prisoners are questioned in their native languages, and as the questioning proceeds, the substance of the conversation is flashed on the screen with English titles. The value of this type of film for the instruction of all military personnel, handling enemy prisoners, is apparent.

Another intelligence film growing out of combat experience is

TF 1-869, Technical Intelligence, Inspection of Enemy Equipment. This film dramatizes the need for keeping from souvenir hunters every bit of captured enemy equipment until such time as the technical-intelligence officer has had the opportunity to examine the same. Story interest is maintained in the film by account of a new type of German fighter airplane, which was giving the Allies considerable trouble. An American fighter pilot scored a hit on the tail of one of these airplanes and caused it to come in for a "belly" landing, minus the tail assembly. From the small number of bullet holes in the fuselage, it did not seem that these were sufficient to cause a structural failure. A few broken pieces of oxygen bottles in the wreck provided a clue that the severance of the tail was caused by the explosion of the oxygen containers. Subsequently, a "mock-up" of the complete fuselage, including the installation of several of these oxygen bottles, when given a burst of .50-caliber machine gun fire, was found to undergo the same damage. Knowledge of this vulnerability resulted in the destruction of many of these enemy fighters.

A number of films treating ordnance problems have been prepared. These utilize high-speed photography for slowing down explosive action. The value of such materials is evident. Ordnance research is facilitated and personnel are better trained to do their jobs. Also, it has been possible to devise safeguards in the handling and use of explosives by this method.

New methods of attacks can be demonstrated as is done in the film *TF 1-892, Minimum Altitude Bombing.* The motion picture also had a role in perfecting the installation and use of the 75-mm cannon in certain types of military airplanes, much to the discomfort of the Nipponeese.

The need for materials of instruction to facilitate the recognition of both friendly and enemy aircraft, ground vehicles and surface craft has long been evident from intelligence reports of friend and foe. Ability to recognize such objects under combat conditions involves a high degree of skill which can only be developed by painstaking and arduous training. To meet this need, the Army Air Forces have developed 2 types of film materials: (1) motion pictures showing both friendly and enemy equipment in motion under different conditions, and (2) film slides depicting the same equipment in characteristic attitudes.

Motion pictures provide vicarious experience in object identification as the trainee will be likely to meet it in combat. Films are also

used in order to test the trainee's efficiency in recognition. A series of research films on problems of recognition also have been developed.

The film slide materials are used in a standard 2×2 slide projector with a variable-speed shutter. It has been found possible to train unselected groups of military personnel to recognize and accurately identify military and naval equipment within a fraction of a second exposure of the slide.

Early in the war film materials on the theory of ballistics and aerial gunnery were requested by authorities in charge of gunnery training. It soon became evident, however, that a minimum of theory and a maximum of practice were necessary in order to train sure-shooting aerial gunners. The great speeds at which aerial combat is waged and the terrific strain under which gunners must function make it imperative that such personnel receive the best type of training which science is able to devise.

Research on the problem showed that in order for a fighter to deliver a lethal burst of fire to an enemy aircraft, the fighter must fly certain specified courses. The best available mathematical minds in studying these courses discovered certain trigonometric functions which could be used to develop a system of sighting and firing and to increase the gunner's efficiency. Involved mathematical equations finally provided data which would enable the individual gunner better to protect himself, his crew, his airplane, and to inflict maximum damage on the enemy.

This led to the production of motion pictures of fighters actually attacking bombers under specified conditions. These materials were photographed in the Southwest under private contract with a special 5-plane camera and constitute the latest developments of their kind. The films were specifically prepared for use in the Waller Gunnery Trainer.

This device was originally developed to provide third-dimensional effects at the New York World's Fair. While not used in its entirety for that occasion, it was later recognized to have value for gunnery training purposes. The projection screen is a concave surface, some 52 ft in base diameter and about 27 ft high. Images of the attacking fighters are projected on the screen by means of 5 projectors providing 150 degrees horizontal and 75 degrees vertical coverage. Four trainees sit in turrets 20 ft from the screen and practice aiming at the incoming fighters. The instructor is able to gauge each trainee's marksmanship and to offer advice during the practice firing. The

handles of each gun vibrate as in actual firing, and an accurate record is kept of the number of hits scored by each gunner. As the hits are registered, each gunner hears a metallic "pip-squeak" in his earphones.

Another AAF development is the gun camera films which have demonstrated their work in the training of pursuit pilots and flexible gunners. These materials are 16-mm films obtained from cameras mounted in the wings of pursuit ships and on the flexible machine guns fired by gunnery trainees. The films thus provide an accurate record of pilot and gunnery sighting skill. After each gunnery mission, the films are developed and projected on a screen for individual analysis by instructors in the presence of the trainees. Mistakes are pointed out and suggestions made for their correction. The materials are considered to be one of the best motivating devices available for stimulating a desire to improve sighting skill. Such records also make it possible to keep an objective cumulative evaluation of individual progress. Other values of the materials consist of ammunition conservation and the reduction of firing accidents with a consequent saving of lives and equipment.

While it is anticipated that the number of training film projects of the AAF will decrease as the war enters its final stages, it is apparent that many new training films will be required and that post-war developments will continue the demand for artistic and technical contributions from the motion picture industry.

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SOME ECONOMIC ASPECTS OF THEATER TELEVISION*

RALPH B. AUSTRIAN**

Summary.—A discussion is given showing how the motion picture theaters of America, once they install large-screen theater television equipment, will be in a position to underwrite and control certain events of great public interest; how theaters will be available as supplementary concert halls, lecture rooms, etc., and how theaters can be employed as remote control fight arenas, race tracks, football stadia, etc. Theaters, having a box office, may be the logical answer to the question of who is going to pay for television.

Allow me to start off with an assumption—which, incidentally, is quite common when discussing television these days—television for the home will, I am sure, become established before theater television becomes general. I believe home television's effect on theater attendance will undoubtedly follow the pattern set by the advent of radio broadcasting, which was no effect at all until several millions of sets were in operation. Then there was a perceptible dip in theater attendance. However, this recession was short-lived and was followed by full recovery and, of course, the advent of sound pictures boosted the level of attendance beyond any previous weekly records.

I believe that within a year or two after home television becomes entrenched, perhaps even sooner, equipment will be available for the satisfactory and showmanship-like exhibition of television images on the large-size screens of motion picture theaters. When this equipment is ready for the market, I feel that the motion picture theater owner—whom I will hereafter call the exhibitor—will avail himself of the box-office possibilities theater television will offer.

I believe all of you are acquainted with the fact that if satisfactory large-screen theater equipment were available today, intracity television would be a commercial reality immediately upon the conclusion of the war. All that theater television needs to become a reality,

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** Executive Vice-President, RKO Television Corporation, New York.

other than the theater equipment itself, is a means of interconnecting a chain of theaters with a camera or cameras located at the scene of the subject matter desired to be exhibited upon the theater screen. Let me read to you but one paragraph from a letter dated March 17, 1944, written by Keith S. McHugh, Vice-President of the American Telephone and Telegraph Company, to Will H. Hays, President of the Motion Picture Producers and Distributors of America, Inc., more familiarly referred to as "the Hays' Office." I quote:

"Knowing the interest of some of the motion picture people in television, I thought you might want to have copies of the attached memorandum outlining the tentative post-war plans of the Bell System for the provision of intracity television network facilities. *Within the same city television can be transmitted over ordinary telephone wires, with the addition of suitable terminal and intermediate equipment, or over special conductors provided for the purpose.*"

This means that a stage show, let us say from RKO's Palace theater, could be witnessed simultaneously in all other RKO theaters in Greater New York, plus as many other independently owned theaters as might desire to tie in on this show in their own neighborhoods. The famous stage presentations of the Radio City Music Hall might likewise be subscribed to by other theaters in Greater New York.

If we now let our imagination wander a little—and yet not let it get out of control—I think we can see where this practice of syndicating stage shows could grow to a final form of national coverage. There are approximately 18,000 theaters located in 10,015 United States cities, affording a total seating capacity of 11,700,000 seats, or one seat for every 12 men, women, and children. There is one motion picture theater open in the United States for every 8000 people. It is not the purpose of this talk to become involved in figures, but I am sure you can see what a vast box-office potential the theaters of the United States can become for events relayed to them by cable.

Suffice to say that the present monthly "take" is approximately \$150,000,000. At the present rate, the theaters of America take in through their box-office windows, in 2 months, more than the entire broadcasting industry does in one year. Resolved to plain hard figures, it means: total motion picture admissions per year, \$1,800,-000,000; total expenditures of advertisers for radio for 1943, \$300,-000,000. The sources of these figures are the Department of Internal Revenue and the *Broadcasting Yearbook*, respectively.

It is interesting to note that as important as the radio broadcasting

industry is—in spite of the fact that it lavishes upon the American public \$300,000,000 in goods and services “for free” each year—John Public still goes out and spends 6 times this much, \$1,800,000,000 per year, for motion picture entertainment. Does that mean that to see as well as hear is worth 6 times as much as hearing alone? Does it mean people would rather mix with other people, rub elbows with them, rather than stay at home? Or is it purely a question of showmanship? Does it mean that the motion picture gives such vastly superior entertainment? Each of these suppositions could form the subject matter of a full-length treatise.

There is invested in motion picture theaters in the United States today \$1,900,000,000. Note please that the collective exhibitor gets his brick and mortar investment back in one year! What I am leading up to is just this: the theaters of America, as you can plainly see, have a tremendous investment and I am sure they are more interested in television and how they can become a part of it than appears evident on the surface.

I think the exhibitor will become one of television's favored beneficiaries. How? Here is an example: There will undoubtedly come into being one or more programming companies, booking offices, agencies—call them what you will—who will have a dual purpose, that of making arrangements with the owners or promoters of such events as prizefights, football games, baseball games, horse racing, etc., and selling these events to the motion picture theaters of America on either a “per theater” or a “per seat” basis.

Let us, for instance, take one single, one-time-a-year event such as the Kentucky Derby. The racetrack at Churchill Downs in Louisville has a very small capacity. The “sport of kings,” however, has a tremendous following scattered throughout the length and breadth of this fair land. Any horseflesh fancier who has ever laid a \$2 bet on the nose of some “nag,” would jump at the opportunity to see the running of the Kentucky Derby. The exhibitors of America—showmen at heart—will not be slow to visualize this tremendous potential box office. Their programming agency would, I am sure, be able to consummate a deal with the Churchill Downs authorities under whose auspices the race is held whereby, for the payment of a rather substantial sum of money, this event would be telecast exclusively to the theaters of America. As I said before, there are approximately 11,700,000 seats. I daresay that the privilege of witnessing the Derby not from a seat somewhere behind a post, or from

the infield without a seat, but from a comfortable chair in one's own neighborhood theater for, let us say, one or even two dollars, would be eagerly accepted.

It would not be a bad seat either, for you can rest assured that the television cameras will be so placed that millions of pairs of eyes in the theaters of America would have a "down-front" seat. As a matter of fact they would have better than a down-front seat. There would undoubtedly be a television camera stationed at each furlong post and the millions of watchers would be literally going around the track with the thoroughbreds. Watching from a theater seat would be infinitely better than from a clubhouse seat at the track. You would hear the frenzied excitement of the crowd, the thundering of hoof beats. You would actually be there without leaving your home town. I feel certain that the Churchill Downs people would be inclined to make this kind of a deal, and I am sure that no sponsor of telecast programs could afford to meet the ante of the exhibitor. Which is a roundabout way of my saying that the event would be shown in the theaters only and would not be telecast for home consumption.

Let us take another example: Madison Square Garden would become merely a studio in which to provide a ring, some lights and a favored few to witness the boxing matches staged in the arena. Millions of fight fans in theaters around the country would constitute the Garden's real audience, not the favored few in the \$30 seats around the ringside. When fights are held in the Yankee Stadium, which seats about 68,000, many are so far from the ring, in spite of the high prices paid, that the fighters look like a pair of dancing mice—when they can be seen through the smoke. These comparatively few thousands will be but a small percentage of the aggregate audience accommodated by the theaters of America—and they will all have a ringside seat. Here, again, the exclusive rights for the telecasting of top caliber fights could be bought by the theaters of America at a price far beyond the capability or willingness of any "good-will" sponsor. In fact, if necessary, the theater owners themselves could promote fights and any other events which they figure would be good box office.

General John Kilpatrick, President of Madison Square Garden, however, has expressed himself as follows: "At Madison Square Garden every year we have at least 65 attractions of definite box-office value for theaters, running for a total of more than 200 days.

We invariably sell out for boxing, basketball, the horse show, the dog show, hockey, the circus, and other events. And there are millions everywhere who would gladly pay money to theaters to see these same attractions by television. Our problem at the Garden is to get the people from the suburbs and out of town to come to see our major attractions. The time and cost of traveling are our biggest handicaps. Theater television will make possible the establishment of Madison Square Garden theater branches throughout the United States. Then our present capacity of 25,000 will be increased to a million or more. And I think that theater owners can count on events that will fill every seat."

The question has been asked, who is going to supply the necessary pickup equipment and personnel to televise these events and carry them as far as the nearest coaxial telephone cable connection? The broadcast chains, or let us call them the telecasting chains, could perform this function but, if they do not desire to do so, the theater group could well afford their own cooperative sets of pickup equipment and their own operating personnel would transport it to the scene of the event, just as sound newsreel cameras are today.

Events of national and international importance should be shown by the theaters, of course, without any extra charge. When our President speaks, naturally the exhibitor ought to include his image and his words as part of the program and schedule the rest of the show accordingly.

I do not believe that there is any doubt that the exhibitor will be quick to realize the advantages of theater television in the post-war period. Today, with our normal peacetime habits disrupted—with some of us working the day shift and some of us the night shift, and the rest of us the graveyard shift—theater attendance has benefited greatly. But there will come a time when we will get back to working 8 hr a day, or less, and we will undoubtedly do this work during the daytime, and the theaters of America may once again experience some slim matinee days. That is the time they will book events which will keep their average weekly attendance up.

Let us take another look: A World Series which might run a maximum of 7 games, or a minimum of 4, would have a potential theater audience, on a 4-game basis, of 44,000,000 people, or on a 7-game basis, 77,000,000. You can reduce this figure by any factor you desire, and multiply it by any admission price you wish, and your answer is still an astronomical figure.

One of the leading figures of baseball has said:

"When the World Series games are shown all over the country by theater television, the amount of money that would be paid into the theaters for the privilege of witnessing these games baffles my powers of multiplication."

And let me add that the exhibitor—clever showman that he is—would probably sell peanuts and hot dogs in the theater to create the proper atmosphere. I assure you the "take" from that source alone would be more than just "peanuts."

How about football? Frank Leahy, former Director of Athletics at Notre Dame University, when asked whether he thought football would fit into the theater television picture, replied in no uncertain terms:

"When 80,000 fans flock to see the Notre Dame-Army game every year, that is just a drop in the bucket compared with the number who would like to see it. As a matter of fact, in the major cities between New York and Chicago there are about 14,000,000 persons who would give almost anything to see this game as it is being played in New York."

Let us not forget the vast audiences who would be just as eager to see the Army-Navy football game and many of the leading inter-sectional and "bowl" games—a simply staggering prospect! And remember, at all these events, no "behind-the-post" seats. Every seat the best in the house. Think of what daytime events of this type will do for theater attendances!

Theaters could also be used in the so-called "off" hours, such as mornings, for lecture halls for the educational networking of television programs. Not all schools have large enough auditoria to accommodate the entire student body but by using neighborhood theaters, teaching by television could be accomplished without the necessity of the school installing expensive equipment at the outset.

Theaters could be used as overflow houses for symphony orchestra concerts, opera, etc. I cite as an example: when Vladimir Horowitz plays at Carnegie Hall, literally thousands are turned away. If this overflow attendance could be taken care of in neighborhood theaters, the theaters would benefit and so would Mr. Horowitz, because of the vastly increased audience. The thought might occur to you that the theater would not be available at the time Horowitz generally plays. I think the answer will be that Horowitz would play when it suits him, which means when he can get the biggest audience. There have

been many morning musicals and I do not think we should worry these days about the time of events. That can be arbitrarily adjusted. We are all going to learn that John Public is the one who sets the time. We in show business will cater to his whims.

Now, let us consider what theater television can mean to the Broadway stage. As popular as *Oklahoma* is, it cannot possibly play in all of the cities in this country where there are people who want to see it, but the very same New York company could appear before the television cameras, simultaneously perhaps with their appearance on the stage at the St. James Theatre in New York, or at a special television theater studio, and their lovely performance made available to all via the motion picture theaters of America—for a box-office "take," of course.

A stock company composed of the leading legitimate stage stars could put on plays here in New York and every motion picture theater in the country would have the opportunity of presenting to its patrons the great names of the legitimate stage, great actors and actresses who could not or would not undertake the rigors of road shows. The possibilities of this phase of theater television alone are limitless and breathtaking!

The question has arisen many times, how will the theater owner charge for these extra events? Will he just include them in his regular admission price? Will he ask an additional admission price when these events occur? How can he time his show, so as not to interrupt a feature picture? These questions I think are academic. A method of timing will be worked out. As for the prices to be charged for these "plus" events, that again is something that will be worked out as we go along. I certainly believe that major sporting events such as I have described could very easily command a premium price and a premium should be paid. The exhibitor can do one of two things: He can increase his regular box-office prices whenever he has television events on the program by an amount varying with the importance of the event, or maintain his present scale of prices and by means of the added television attractions, play to more people per year, thus producing more new theatergoers and increasing his "rate of occupancy" and increasing his earning power per seat per month.

As an example, a hotel can break even with an annual average occupancy of 60 per cent. Additional room sales are just so much "gravy." The average occupancy of United States hotels during the "Golden Twenties" was only 70 per cent. In the depression it was

less than 50 per cent. Today it is running at a fabulous 90 per cent against 60 per cent in relatively prosperous 1939. It can readily be seen therefore that anything an exhibitor can do to boost his rate of occupancy a few per cent results in considerably more monthly income per seat.

There are still those who believe that home television or theater television will hurt the motion picture business. I am not one who shares this view. It is now pretty well established that radio has not hurt the motion picture business and yet it is a device designed to keep people in their homes. Properly used, radio has helped the picture business. Within the last year motion picture companies have awakened fully to the tremendous possibilities offered by radio for the exploitation of their product.

Television will bring hundreds of new personalities to the public eye, the same as radio did. Many a picture star has reached the level of stardom via radio broadcasting. For example, in the 1944-1945 program of RKO Radio Pictures, the following feature or star personalities achieved their popularity via the air waves: Charles Winninger, Fibber McGee and Molly, Bing Crosby, Bob Hope, Frank Sinatra, Joan Davis, Dennis Day, Vera Vague, and Lum and Abner. An examination of the product announcement of other motion picture companies will reveal many more names drawn from the field of radio broadcasting.

One final observation: I have spoken so far about theater television in relation to sporting events, news incidents, outdoor happenings, concerts, *etc.* I now want to talk a little about the exhibitor's influence upon home telecasting of all kinds. It is not beyond the bounds of possibility to visualize a nation-wide chain of theaters seeking home television personalities as fast as they are developed, and paying them enough to make it worth their while to perform for theater audiences rather than for the home audience. For example, one of the highest priced comedy radio shows today represents a weekly program cost of about \$25,000. When you add the transmission charges, it becomes a lot of money for any commercial sponsor to pay for a half-hour once a week. If the exhibitors felt that they could get five or ten cents a seat more, or merely increase their attendance without raising their scale of prices by booking that personality to appear for theaters only, for a half-hour once a week, they could offer him considerably more than \$25,000 for a half-hour show and could then emblazon their marquees with the announce-

ment: "Jack Benny & Co." (or whoever the Jack Benny is when this situation becomes possible)—"Not at your home, but here." And I really think that it could become possible.

Television must not be thought of as the exclusive instrument of the broadcasting industry or, as a matter of record, of any other industry. Television is too big, too all-encompassing, too international in scope to be controlled by group interests. Airplanes were invented primarily for transportation purposes. Today they are winning the war by destroying and killing. Certainly the Wright Brothers never thought of that. The original concept of television was that it would enable millions to see from their homes events taking place at far distant points. I am inclined to believe, however, that many have forgotten this so-called "closed circuit" use of television I have been delineating.

Perhaps some of you are saying to yourselves that I am engaging in some wild flights of prophecy but I think if you reflect gravely upon the fact that there *are* 18,000 theaters in this country that *do* have 11,000,-000 seats, that *do* represent an investment of \$1,900,000,000, that *do* take in today \$150,000,000 a month at their collective box offices, you will realize that the theater owner of America, the exhibitor—a master showman who has progressed in a few years from being the lessee of an empty shoestore, exhibiting crude flickering images, to being the operator of *de luxe* air-cooled palaces presenting masterpieces of showmanship—is not going to let television pass him by or freeze him out. He and he alone has the one thing which has bothered many of those who have studied the economics of television. He has the answer to the question, "Who is going to pay for television?" *He has a box office!*

PROGRESS REPORT OF THE WORK OF THE ASA WAR COMMITTEE ON PHOTOGRAPHY AND CINEMATOGRAPHY-Z52*

J. W. McNAIR**

Summary.—This report discusses the progress of activities of the ASA War Committee on Photography and Cinematography-Z52 up to October 1944. Many of the projects described have since been approved as American War Standards while others are in the final drafting stage. A complete list of all the approved standards, and the status of unapproved projects, may be obtained from the American Standards Association, 70 East 45th St., New York 17.

When D. E. Hyndman, Engineering Vice-President of the SMPE, discussed the work of the War Committee on Photography and Cinematography at your technical conference last April,¹ he told you of the many projects which had been undertaken by subcommittees of this committee in order to prepare war standards and specifications for the use of the Armed Forces in the field of both still and motion picture photography. Mr. Hyndman's remarks were supplemented by those of Captain Lloyd T. Goldsmith, member of your Standards Committee and Chairman of the Armed Forces Committee on Photography and Cinematography; John A. Maurer,² Chairman of the SMPE Nontheatrical Committee and Chairman of the Z52 Subcommittee *B* on 16-Mm Sound; M. R. Boyer,³ member of the SMPE Standards Committee and Chairman of Z52 Subcommittee *C* on 16-Mm Laboratory Practice; A. G. Zimmerman,⁴ member of the SMPE Standards Committee and Chairman of Z52 Subcommittee *D* on 16-Mm Projection; and J. M. Whittenton,⁵ member of Z52 Subcommittee *G* on Exposure Meters.

At the time of the conference, none of the work of these subcommittees had yet been completed and approved as American War Standards. Today I have pleasure to report that 25 American War Standards and specifications in the field of still and motion picture

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** Secretary, War Committee on Photography and Cinematography, American Standards Association, New York.

photography have been approved by the American Standards Association as the result of the work of the various subcommittees of Z52, in which many members of the SMPE played a very great part. It is expected that 15 more war standards will be completed and approved by January 1, 1945, and that approximately 25 more will be completed in the first 3 months of the coming year.

Of the standards already approved, 18 relate to 16-mm motion pictures. These include a specification for portable service model, 16-mm sound film projector which has been approved by the Joint Army-Navy Committee on Specifications as a Joint Army-Navy Specification JAN-P-49, and a specification for 16-mm release prints which has also been approved as a JAN Specification, JAN-P-55, and is already in use by the Armed Forces. Bids have been asked by the Signal Corps for development of the service model projector, and it is understood that more than a half-dozen bids have been received.

Among the other 16-mm war standards are four for the various printer apertures used in reduction and contact printing of 16-mm prints, a standard test method for determining freedom from projector travel ghost, a test method for determining picture unsteadiness of projectors, a test method for determining uniformity of scanning beam illumination, and a test method for determining the resolving power of 16-mm projector lenses. The test film and plates needed for the travel ghost, scanning beam illumination, and resolving power tests have been prepared by Mr. Maurer for the Society and will be furnished the Armed Forces through the SMPE. The unsteadiness test films are being furnished by the Bell and Howell and Eastman Kodak companies.

Mr. Maurer has also produced for the Society a 3000-cycle flutter test film, a multifrequency test film, a buzz track test film, 2 sound focusing test films, and a 400-cycle signal level test film in accordance with specifications developed by Z52 Subcommittee B. These, also, are being furnished the Armed Forces through the Society, as are the test leaders for 16-mm reduction prints required by the leader, cue, and trailer specification I mentioned earlier.

A standard specification for a 16-mm test film for field checking of projector adjustment has also been approved, which is comparable to the 35-mm theater test reel of the Research Council, Academy of Motion Picture Arts and Sciences; test films in accordance with this specification are now being furnished to the Armed Forces by the Research Council.

As a result of the work which was done under the guidance of the War Committee on Photography and Cinematography, there is now available a set of 16-mm test films which, if not better in certain respects, is fully the equivalent of those available today for 35-mm work.

The other approved 16-mm standard is probably the most important from the long-range viewpoint. It is a standard for the sound records and scanning area of 16-mm release prints. The cooperation shown by all concerned in the formulation of this particular standard, resolving as it does long-standing differences of opinion, was very remarkable; and the Armed Forces have expressed their appreciation of the manner in which the controversial questions were amicably settled.

Two war standards in the field of 35-mm motion pictures which have been approved are for the camera photographing aperture and the projector picture aperture. These standards recognize essentially the existing recommended practices on these 2 apertures which were developed by the Society and the Research Council.

Four standards for photographic exposure meters have also been approved. These include a standard for the acceptance of reflected-light type meters, a standard for the calibration of reflected-light type meters, a standard for the abuse-testing mechanism, which was demonstrated here by Mr. Whittenton last April,⁵ and a standard specification for service model meters for the use of the Armed Forces, which has since been approved as Joint Army-Navy Specification, JAN-M-58. Initial orders have been placed under this specification.

Among the war standards in the field of motion pictures which are expected to be completed and approved before the first of the year are standards for film nomenclature used in studios and processing laboratories,⁶ for leaders, cues and trailers used in direct 16-mm production, for 16-mm projector reel spindles, and for 16-mm reels and containers. Also near approval are standards for sizes of screens and for the whiteness and brightness characteristics of semidiffuse projection screens.

Among the still photography standards which are expected to be completed shortly are specifications for contact printers, photographic enlargers, slide-film projectors and slide films, as well as standard methods of testing between-the-lens and focal-plane shutters, and complete specifications for photographic flash lamps.

Among the other proposed standards now under way of interest to the members of the Society are specifications for an arc model 16-mm projector to be used by the Armed Forces, a specification for a 16-mm warble test film, and standards for quality control of 16-mm sound motion picture prints. Proposed standards for the sound record and scanning area of 35-mm sound prints will also be drafted by Subcommittee *B*.

Other standards under development include proposals for the size and shape of 16-mm camera and view-finder apertures, the size and shape of 35-mm view-finder apertures, the registration distance of 16- and 35-mm camera lenses, 16-mm camera and recorder magazine mounting dimensions, specifications for photographic filters and safe lights. Under way also are proposals for methods of testing camera noise and a complementary standard for the noise limits for cameras, specifications for photographic chemicals, specifications for photographic flood lamps, specifications for photographic trays, tanks, thermometers, and many others. A complete list of all the approved standards is available from the ASA offices on request.

As you can see from the brief list of projects I have given, the work of the War Committee on Photography and Cinematography covers an extremely broad field. Committee members and members of the various subcommittees and subgroups have been quite busy in preparing the standards and specifications which the Armed Forces desire.

You can all be proud of the part which the Society, its officers and its members have played in the past year in helping, first, in the formation of the War Committee on Photography and Cinematography and, then, in the work of the committee and its subcommittees once it was organized.

Under this wartime procedure, accelerated progress has been made in preparing numerous standards which will be suitable for peacetime use and recognition either as regular Recommended Practices of the Society or as regular American Standards, under the Society sponsorship of the Sectional Committee on Motion Pictures, Z22.

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DEVELOPMENTS AT THE NATIONAL FILM BOARD OF CANADA, 1939-44*

RAYMOND SPOTTISWOODE**

Summary.—Since its formation in 1939, the National Film Board of Canada has been responsible for the coordination of all Dominion Government film activity, and the production of the great majority of films made for Government Departments and for the Armed Forces.

The Film Board's annual output now is about 250 films. Of its 2 theatrical series, one is distributed in some 800 theaters in Canada, and the other in some 5000 theaters in the U. S. besides. Its nontheatrical films are distributed through 120 mobile projection units in all parts of Canada.

The staff of the National Film Board has grown from about 40 to 600 persons during the period under review, and the Board's work now includes the production and distribution of still pictures and film strips, the preparation of posters and displays, and the distribution of motion pictures all over the world. In the film production field, the Film Board overcame certain handicaps resulting from lack of equipment and previously trained personnel by methods which may be of value to engineers charged with the technical development of new motion picture industries abroad.

During the past 4 years, the National Film Board of Canada has gained many times over from the technical assistance which has been freely given it in this period of development by members of the Society and other engineers in the profession. Now the time has come to render some account of what we have done up in Canada, and of what we plan to do in the post-war world.

The Film Board has followed quite a different course of development from most of the U. S. movie-making agencies whose expansion has been so well described to the Society during the last 2 years. It has had the advantage of being a centralized agency, charged with abolishing overlapping and waste, and getting films made wherever they could be made quickest and best. But, in its own film-making capacity, it has had to get along with equipment and resources which would have been considered wholly inadequate in most other countries. Working within the practical limits of a population of 12

* Presented Oct. 16, 1944, at the Technical Conference in New York.

** National Film Board of Canada, Ottawa, Canada.

millions, it could not afford to buy the equipment first and make the films afterward. It had, first of all, to satisfy the urgent demand for films by stretching machinery and manpower almost to the breaking point.

Back in 1941, a 4-reel review of the second year of the war was produced in little over a week by the entire staff splitting up the cutting processes between them—editing, music, effects, negative, and so on—and putting themselves on 20-hr shifts to do it. A year before that, our chief engineer would often find himself awakened in the middle of the night to come down to the Board and fix a broken printer working on a late shift. Arriving, he would go out into the back yard, clip off a piece of barbed wire fence, file a cotter pin out of it, and set the printer going again. Those days have gone now, but the people who worked in the Film Board then are the nucleus of the present organization, which has thus come to lay less stress on equipment and expert training, and more on resourcefulness and human energy.

There is no special virtue in this. We have often had to do a job in the long slow way when equipment and skill would have done it faster and better. Pulling yourself up by your own efforts means making a long string of mistakes, and accepting lower technical standards until you have learnt to do a thing the right way. We have often looked with envy at the resources and trained talent which the U. S. has put into the picture-making field in the Armed Forces and the government during the war years. My only excuse for inflicting on you this tale of our trials is to repay the debt of help which you have given us and to bring before you a few practical experiences such as many of you may encounter for yourselves over the next few years.

Without question, American motion picture engineers are going to be called on again and again to install equipment in countries with practically no movie-making experience. It will be their job—as it has often been before in other fields—not merely to put the equipment in and get it running, but to train men who will keep it running and develop it over subsequent years. To be able to help and plan along these different lines, engineers may be interested to hear something of the general development of an organization which itself sprang up in new territory.

There was a long history of film making in Canada prior to the war. The Dominion Government was one of the first to add a film unit to

its departments, having kept one going steadily since 1918. Highly professional commercial films have been made for the last 15 years by Associated Screen News in Montreal and by one or two smaller companies in other parts of the Dominion. But, by and large, there was no trained reserve of film-making skill to draw on when the Film Board came into existence early in 1939—as a result of an Act of Parliament known as the National Film Act.

This Act empowered the Film Board to coordinate all Canadian Government film activity, and to promote the production and distribution of such films as were called for in the national interest as a source of information to the public. Four months later war broke out, and the Film Board had a nation-wide job laid on its doorstep. A mass of new government controls had to go suddenly into effect, changing the way of life of every farmer, every business man, every housewife in the land. Along with all other channels of public information, films were called into service to explain necessities, methods, and results.

The most direct avenue to the people at large was through the movie theaters, and the motion picture exhibitors played their part magnificently in making screen time available for these statements of public policy. The Film Board, in its turn, fully recognized that minutes in the theater were precious, and agreed to a presentation of one "2-reeler" (later increased to 2) per month, together with one $1\frac{1}{2}$ -min newsclip per week attached to the regular newsreels.

More important, the Film Board acknowledged the fact that each distributor and theater manager must stand behind the product he exhibited, and could not accept films of lower standards than those set by the commercial production centers of Hollywood and New York. It was therefore agreed to distribute the 2 theatrical series through two of the regular distributors, Columbia Pictures and United Artists, whose sales representatives normally see their pictures each month before recording, so that they can advise on titles, release dates, and other details of exploitation. In this way a very cordial relationship has been built up between the Film Board and the trade, which has resulted in the distribution since early 1940 of nearly 75 pictures, most of them 2-reelers, not to mention more than 200 newsclips. These pictures have been shown in between 600 and 800 of the 1200 theaters in Canada, and reach a monthly audience of $2\frac{1}{2}$ millions.

To maintain high standards of showmanship, the idea of public

information has been interpreted in the broadest sense. The subjects of the theatrical films have ranged from analyses of the psychology of enemy countries to reports of the part played by the different services in current military campaigns; and from recruiting pictures to stories of Canada's natural resources and their development before and during the war. One of the 2 theatrical series treats mainly of Canadian affairs, the other of world affairs. The latter series (beside its Canadian outlets) now plays in more than 5000 U. S. theaters through commercial distribution channels.

Of the 250 or so pictures which the National Film Board produced last year, about 50 were weekly newsclips on war loans, price fixing, and other government campaigns; 25 were theatrical information pictures; and the remaining 175 were pictures aimed at the great audiences outside the theaters which are now reached by mobile projection units. About 120 of these units are today in the field, fed from 40 regional libraries and showing films to a quarter of a million people a month in rural areas, as well as the same number of industrial workers. When these figures are set against a total population of 12 millions, they represent a significant achievement for a project less than 4 years old.

The films shown on these 120 rural and industrial "circuits," as we call them, are of the most diverse character possible. Many of them are your own pictures: the products of your Armed Forces film units and their industrial incentive divisions. Many are made for the British Ministry of Information for its own similar rural and industrial screenings. But the great majority of these pictures are produced in Canada by the National Film Board, and cover all phases of the national life which are of interest to these particular audience groups. The building and flying overseas of the first of the great Lancaster bombers produced in Canada; the yearly cycle of a habitant farmer's life in Quebec; the functioning of the new Unemployment Insurance Act as seen through a typical worker's eyes: these are characteristic examples of the subjects put on the screen by the Film Board in the last year or so.

Month by month they go out to the people of Canada in compact cans of 16-mm film. But they are not simply messages doled out from a central bureau in Ottawa to an unresponsive public. Wherever they are shown there is a lively and constant give-and-take. The projectionist is far more than a machine-minder. He talks to the local schoolmaster and minister. He awakens their interest to

what can be told through the screen. He advertises his shows and hooks them up with the local county fair, or YMCA meeting, or bingo game, or whatever it may be. He has booklets about his month's program of films, giving background information and suggesting subjects for debate. And he is usually to be found helping with the formation of a discussion group, which goes on holding regular meetings until he makes his monthly round again. Thus, what might have started out as a rather drab and mechanical screening of films has become a living part of the community's life, a real education in the business of civics—the linking of people together in a common social purpose.

This 2-way traffic of information and advice—and criticism, too—is kept going by monthly reports from the projectionists of what they have picked up from audiences on their circuits. And every year, at regional conferences across the country, there is a general get-together of people going out from the Film Board in Ottawa to meet these rural and industrial projectionists who are also members of the Film Board staff and have a common interest in the practical business of film making. A projectionist will tell a producer that his pictures would go down better if he put more humor into them; or he will report to one of the laboratory staff that the prints coming through are too dark for halls where it is impossible to close out all the stray light. By rotating the representation, a large number of the Film Board staff have thus been brought face to face with their best friends and critics—the men who have gathered together and talked to the more than half a million Canadians who see their pictures every month.

I have purposely worked inwards gradually from the circumference to the center, for I have wanted to show how we have tried to conceive of film making as a cooperative business in which audiences played a purposeful and formative part—the theater audiences through commercial distributors and the nontheatrical audiences through projectionists and leaders of discussion groups. This cooperative spirit has also become the basis of production at the Film Board itself—not, Heaven forbid, through any special display of virtue, but simply because technical skills have been spread so perilously thin that they had to be shared as widely as possible. Of the present production staff of more than 200, only about a dozen had ever seen a frame of film before they joined the Film Board within the last 4 years—and this includes such technical branches as sound recording, the labora-

tory and optical effects, as well as those concerned strictly with production itself.

Two principles have guided the development of film skills from the start: maximum interchange of information between everyone, and maximum individual responsibility for everyone. There is a constant transfer of staff between departments. Our present personnel manager has been successively head of the negative cutting department, the film library, and the laboratory. The laboratory staff has frequently exchanged members with the camera department, and directors and script writers have often handled cameras. Shifts of this kind mean constant training and retraining, and are sometimes disconcerting to those who have to plan continuity of production. But they have supplied an invaluable versatility of skill and have certainly helped to prevent the Film Board from getting stale and falling into a rut.

Maximum responsibility has been most evident in production. The entire film program for the year is divided up between separate production units, which have multiplied until they now number about a dozen. These units divide the film-making field according to function: two handle the 2 theatrical series, a third, films for the Armed Forces, a fourth, films on economics, a fifth, reconstruction and stabilization, and so on. Each of these units is self-contained, and comprises a producer, a business manager, and a versatile staff from which the necessary script writers, cutters, and directors can be found. By interchanging skills, a unit of six can handle a program of 4 or 5 films at once.

The production unit, through a liaison officer, often makes its own initial contact with a government department for the making of a film, acting under general guidance in policy from the Commissioner and Deputy Commissioner. The unit budgets its new picture, and is solely responsible for holding to this budget with the aid of weekly reports from the accounts department. From the beginning, the producer steers his film himself, negotiating the script, choosing director, cameraman, and composer, and supervising the editing and sound recording. Only at this final stage does he call in the Commissioner or his Deputy for approval, and if any changes have to be made, they are invariably made by the unit itself. This kind of self-determination has had excellent results. It has developed individual styles. It has trained people in the rough school of "sink or swim." It has given producers a fine sense of how to discharge a public

service. Ottawa is a small and friendly capital. At half an hour's notice you may find a Minister or his Deputy dropping into the screening room to see and discuss the rough-cut of a film you are making for his department. And to present your unfinished, soundless film in a true light, you must have a very clear sense of the "why" and the "how" of what government is trying to do.

As much as possible of the same sense of individual responsibility is encouraged in the technical departments. But while it has not been found necessary to have any kind of over-all production manager, there has had to be more coordination on the technical side. This is because so many problems arise which are of common concern to several technical departments. Moreover, technical progress and difficulties must be kept before producers, and this is best accomplished by someone who broadly represents the interests of all technical skills. Within this loose supervision, however, the technical men plan their own progress and decide just what equipment they propose to install under the limitations imposed by their share of the budget. They handle their own schedules of hours and shifts and set up their own committees to deal with such matters as standards and procedures of work. It has been our practice to pick only the keenest and most intelligent men and women, and then give them their head as quickly as possible. This devolution of authority has developed the skills of the better workers with a speed which has proved astonishing. Today, our laboratory, with a staff of nearly 40 and running smoothly to a total output of nearly a million feet a month, contains only 3 people who have had more than 3 years' experience in film. This is characteristic of every department.

These, in broad outline, are the keynotes of the Film Board's administration as far as film production is concerned.

A few words should be said about the equipment which the Film Board has to work with in carrying out its production program. The largest department, the laboratory, operates under the handicap of having no 35-mm release footage to print, since the Film Board has always held that, when commercial firms distribute its products, they should also be given the handling of the release printing and processing. Consequently, the whole laboratory footage is always going up and down according to the varying rate of production, making control much more difficult than it might be. The average monthly 35-mm footage is 600,000, handled on only 2 developing machines, though a third reconditioned machine will shortly be brought into service. In

addition, two 16-mm machines deal with a monthly footage of about 200,000, a figure which has been held down by the inadequacy of our 16-mm printing equipment, which up to now has proved impossible to replace.

The 5 developing machines are connected to a modern continuously replenished circulating system, with thermostatically controlled interchangers, to which recording instruments are being added. Two of the three 35-mm machines are of the 2-tank type, and the piping allows the greatest flexibility in circulating the 3 kinds of developing solution. This is necessary because 9 types of stock have at present to be developed in 2 machines.

The positive and negative developers are of the standard *D-16* and *D-76* types, but to develop variable-density sound we adopted a few months ago the metol-only type of developer pioneered by Columbia Pictures. This has given us very satisfactory results. Hourly *pH* readings are taken of all solutions, of hypo and of wash water, as are regular gamma strips, and all the results are graphed and collated. Supplementing these rapid checks, a complete program of chemical analysis has been started, based on the opacimetric and potentiometric methods of end-point determination described in recent years in papers read before the Society.

Our sound recording department uses Western Electric variable-density track, and has one fixed channel of the old *QB* type, one more modern *Q* recorder which is mounted in a truck and trailer, and 2 single-system newsreel recording units. Rerecording has to be carried out with only 3 dubbing heads, calling for prodigies of skill on the part of the sound cutter—not to mention the mixer!—in handling very complex sounds with so few channels.

Of the many other technical departments, the library perhaps deserves to be singled out. We now have about 15 or 20 million ft of catalogued film containing the Canadian Government records of the last war, and of the heroic exploits which opened up the Northland in the succeeding 20 years. To these archives has been added a large collection of captured enemy material, which is specially rich in the years before the U. S. entered the war. Finally, there is an enormous footage collected from the American Armed Forces film units, and an even bigger footage shot by ourselves and covering every branch of Canadian participation in the war. All this material is fully "dope-sheeted" and catalogued, and is available, not only to our own producers, but to film makers all over the continent, at very short notice.

The Animation Department is unconventional, in that it prepares practically no cell animation of the orthodox type for shooting under the animation camera. Cell animation requires a large staff to make it effective and economical, and a group which has grown to a current level of only 10 persons cannot achieve a large output with cells. On the other hand, 10 artists of exceptional originality and skill have devised or perfected many new animation techniques. Cut-outs, light boxes, elaborate scratch-off maps and diagrams, hand animation drawn on the film itself; these are only a few of the methods currently used by Film Board animators. Much of their output consists of French-language folk songs, English-language sing-songs, and other light and amusing material for the traveling circuits.

Animation is carried out on a zoom-stand type of camera with the usual accessories. This camera runs almost continuously throughout the 24 hr, since the animators produce many of their effects by actual manipulation under the lens, which economizes in art-work time at the expense of camera time. Unorthodox as these methods are, they have been brought to produce a remarkably high degree of technical perfection.

These and the other technical departments, as well as the production staff, are housed in an old lumber mill on the banks of the Ottawa River. While this mill was roomy enough for the 30 or 40 members of the former Motion Picture Bureau, it is hopelessly overcrowded by its present staff of 200. The flimsy wooden partitions which were hastily built during the early years of expansion, and the unvented interior cutting rooms, formed a very serious fire hazard. The conversion of this old building into a fairly safe structure was a difficult business, and involved rebuilding the whole of the inside while the 200 people continued to work.

The experience of the last 3 or 4 years—of having to learn everything from the bottom, and of having to use resourcefulness when there was no proper equipment to do the job—all this has been of inestimable value to the staff. It has led to a give-and-take which has prevented individuals from getting overspecialized, and has speeded up the development of unexpected skills. In our music cutting rooms, you will find the former first violinist of the Toronto Symphony Orchestra chopping up sound tracks with the best of them, building an effects track from the merest bits and pieces because he knows that the rural circuits can only spend \$500 on their new picture, and so must economize in sound costs. And in his spare time

you will find him leading the newly formed Ottawa Philharmonic Orchestra. Another member of the music department, a young Canadian composer, had never written a note of music for film until a couple of years ago. He has now completed his second score for a feature picture in Hollywood.

The lesson of all this is that films of professional standard can be produced in large numbers by people with little previous film-making skill. There may be encouragement in the example of the Canadian Film Board example for all who are starting new units of production after the war in the fields of visual education or public relations, or who are helping to build a new movie industry in the many countries which have still scarcely made a beginning of projecting their national stories and ways of life on the screen.

This paper has dealt only with the film production side of the Film Board's work. The Board has many other activities, including production and distribution of still pictures and film strips, the making of posters, and the designing and presentation of graphic displays. These last are used in such campaigns as those against careless talk and sabotage, against syphilis and other diseases, and are linked up with specially produced films. Finally, it is useless to make films if you do not see that they are projected at the right time, in the right place, and to the greatest number of people. This is the job of the Distribution Department which is the link with the theaters, the rural and industrial circuits, and the legations and trade commissions abroad.

All this work has an important place in peace as much as war. We look to continued expansion of these activities, especially in the educational field.

New horizons are opening in the post-war world: town planning, housing, public health, community centers, soil conservation, and a hundred other outlets for the energies developed and harnessed during the war. To all these, films can make a specific contribution. They will become a vehicle of interchange between nations, showing the work in which each nation excels. They will be shown in schools, factories, and civic groups—wherever people meet together to discuss their common professional interests. And, in satisfying this very human need, they will complement and not compete with the equally human need of entertainment. In this nonoverlapping area there is room after the war for many new production groups, which may perhaps learn something of value from the National Film Board of Canada and its work.

CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

The editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D. C., or from the New York Public Library, New York, N. Y., at prevailing rates.

American Cinematography

26 (Mar., 1945), No. 3

- Where Will You Fit in Television? (p. 80)
Production Designing (p. 82)
Photographing Tokyo from the Air (p. 86)
Requirements of Educational Film Presentation (p. 87)

I. BROWNING
E. GOODMAN
R. H. BAILEY
O. BELL

Bell Laboratories Record

23 (Feb., 1945), No. 11

- The Ribbon-Frame Camera (p. 40)

F. RECK

Electronics

18 (Mar., 1945), No. 3

- Direct-Reading Color Densitometer (p. 102)
Engineering Aspects of Television Programming (p. 107)
Tracking Angle in Phonograph Pickups (p. 110)

M. H. SWEET
V. M. BRADLEY
B. B. BAUER

International Photographer

16 (Jan., 1945), No. 12

- Monopack as a Medium for Three-Color Processes (p. 12) W. J. KENNEY
17 (Feb., 1945), No. 1
High Turbulation Developing (p. 18) W. J. KENNEY

International Projectionist

20 (Feb., 1945), No. 2

- Auxiliary Sound Requirements of the Motion Picture Theatre (p. 7)
How to Make Your Own Schematic and System Diagrams (p. 13)
Projectionists' Course on Basic Radio and Television—Pt. 8: Direct Current Meters (p. 18)

H. B. SELLWOOD
L. CHADBOURNE
M. BERINSKY

Photographic Journal

85B (Jan.-Feb., 1945), No. 1

- Colour Development (p. 13)

A. G. TULL

SOCIETY ANNOUNCEMENTS

ATLANTIC COAST SECTION MEETING

A large gathering of members and guests of the Atlantic Coast Section of the Society heard Dr. A. H. Rosenthal, Director of Research and Development, Scophony Corporation of America, discuss problems of theater television projection equipment at the meeting held on March 21. Dr. Rosenthal presented a paper which explained methods of overcoming certain limitations of theater television projection, such as the size, brightness, and definition of television images. He described 2 systems employing the principles of optical storage and light modulation, Supersonic system and Skiatron, developed by Scophony.

Dr. Rosenthal, a Fellow of the Royal Astronomical Society of London, who has designed an apparatus applying television technique for the investigation of the sun's surface, covered many miscellaneous aspects of his subject during the discussion period which followed the paper. It is planned to publish this paper in a forthcoming issue of the JOURNAL.

The meeting, held in the Roof Garden of the Hotel Pennsylvania, New York, opened with a showing of the documentary film, *Letter to a Hero*.

EMPLOYMENT SERVICE POSITIONS OPEN

Young man with several years' experience in Motion Picture Camera and Projector design. Must have mechanical background with a knowledge of motion picture industry requirements. Write or telephone for interview. Akeley Camera, Inc., 175 Varick St., New York 14, N. Y. WALKER 5-7954.

Optical engineer's assistant. Acquainted with optical laboratory routine, ray tracing and similar problems in related scientific fields. Reply to Optical Engineering Department, DeVry Corporation, 1111 Armitage Ave., Chicago 14, Ill.

Position open for man or woman with experience in optical instrument design. Position also open for man or woman with experience in lens design or computing. Write for interview. Binswanger and Company, Optics Division, 645 Union Ave., Memphis, Tenn.

Physicist with special training in optics for research on utilization of carbon arcs particularly in projection systems. Apply to Research Laboratory, National Carbon Co., Inc., P. O. Box 6087, Cleveland 1, Ohio.

POSITION WANTED

Engineer desires position with manufacturer or theater circuit supervising construction, maintenance, or operation. Sixteen years' experience. For details write P. O. Box 710, Chicago, Ill.

COMMITTEES OF THE SOCIETY

(Correct to April 20, 1945)

« »

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Vol 44, No. 5

CONVENTION.—To assist the Convention Vice-President in the responsibilities pertaining to arrangements and details of the Society's technical conventions.

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EXCHANGE PRACTICE.—To make recommendations and prepare specifications on the engineering or technical methods and equipment that contribute to efficiency in handling and storage of motion picture prints, so far as can be obtained by proper design, construction, and operation of film handling equipment, air-conditioning systems, and exchange office buildings.

(Under Organization)

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HISTORICAL AND MUSEUM.—To collect facts and assemble data relating to the historical development of the motion picture industry, to encourage pioneers to place their work on record in the form of papers for publication in the JOURNAL, and to place in suitable depositories equipment pertaining to the industry.

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LABORATORY PRACTICE.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture printers, processing machines, inspection projectors, splicing machines, film cleaning and treating equipment, rewinding equipment, any type of film handling accessories, methods, and processes which offer increased efficiency and improvement in the photographic quality of the final print.

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Room 813
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* Advisory Member.

May, 1945

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NONTHEATRICAL EQUIPMENT.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of 16-mm motion picture projectors, splicing machines, screen dimensions and placement, loudspeaker output and placement, preview or theater arrangements, and the like, which will improve the reproduced sound and picture quality of 16-mm prints.

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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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COAXIAL CABLES AND TELEVISION TRANSMISSION*

HAROLD S. OSBORNE**

Summary.—Communication techniques and facilities useful to the entertainment industry have evolved naturally from the Telephone Companies' main objective—the transmission of speech. The development of carrier systems for long-distance transmission and technical features involved in the latest carrier medium—the coaxial cable—are reviewed. The television transmission capabilities of this medium, both now and what may be expected shortly after the war, are mentioned. The extensive system of such cables planned for the next 5 years, supplemented by radio relay systems to the extent that these prove themselves as a part of a communications network, will provide an excellent beginning for a nation-wide television transmission network. Planned primarily to meet telephone requirements, this network of cables will be suitable to meet the transmission needs of the television industry.

Let me first express my pleasure in your invitation to take part in this conference and my admiration of the progressiveness of this organization. This progressiveness in the application of the growing list of scientific aids in providing entertainment to the public is illustrated by your consideration here of television and, indeed, by the whole program of the conference.

HISTORICAL

Apart from the use which you make of our message-telephone and private-line services, the principal role of the Telephone Companies in helping the entertainment industry is in providing facilities for the transmission of programs throughout the country. Some of the first uses of the telephone were in transmitting programs as the climax of lectures and demonstrations by Alexander Graham Bell. This type of use continued and increased, and has blossomed into the large nation-wide networks used daily by broadcasters.

* Presented Oct. 16, 1944, at the Technical Conference in New York.

** Chief Engineer, American Telephone and Telegraph Company, New York.

This development of program transmission service is a natural evolution from the first main problem of the Telephone Companies—the transmission of speech. For many years, the research engineers of the Bell System have studied the characteristics of speech and the requirements for its transmission over electrical circuits. They have learned how to make the transmission and reproduction of speech, over any distances, as nearly perfect as desired. They have determined quantitatively how much improvement in clearness and naturalness results from any given technical change, such as increases in the band of frequencies transmitted, as a part of the work leading to the progressive improvement of the transmission and reproduction characteristics of telephone instruments and of the millions of circuits used to interconnect them throughout the country and to other parts of the world.

It was a natural extension of this work to determine the requirements for the faithful transmission of music and of other sounds as well as of speech. As a result, the technical equipment of the Telephone Companies for the transmission of programs was repeatedly improved and, with the advent of the amplifier and loudspeaker, a considerable amount of this service was given even before the days of radio broadcasting. An interesting illustration was the transmission of the ceremonies which took place on Armistice Day, 1921, at the Burial of the Unknown Soldier in Arlington Cemetery. By loudspeakers the ceremonies were made audible to approximately 100,000 people at the Cemetery and were transmitted by telephone lines to a crowd of 35,000 people at Madison Square Garden, New York, and to a crowd of 20,000 people in San Francisco.

Today, the situation as regards television transmission is somewhat similar to that relating to the transmission of sound programs in 1920. We have a transmission system suitable for transmitting the video signals in networks throughout the country. Limited demonstrations of such transmissions have been made with success. We believe that we are prepared to provide the television industry with satisfactory transmission networks throughout the country if and when the development of the industry results in a need for them. As in the case of sound-program transmission circuits, we have arrived at this position in large part through the work done to improve our telephone-message business.

I think you will be interested in a brief review of how the Telephone Companies came to carry out this development. The develop-

ment of the vacuum tube as a telephone amplifier, the development of electrical filters and other basic improvements in technique gave a great stimulus nearly 30 years ago to a problem which had long been in the minds of inventors—multiplexing several telephone channels on one pair of conductors. This line of development has had tremendous success resulting in a wide application of these multiplex systems to telephony. The systems used are called "carrier systems" because the basic principle is that the telephone currents of different channels modulate various higher frequency currents which are called "carrier currents." By this means, the band of frequencies required for each telephone transmission channel can, in effect, be moved up to any desired point in the frequency range without changing the width of the band. By the selection of suitable carrier frequencies and by vast attention to the minute requirements of the design, channels of telephone conversation may be closely stacked one on top of another in the frequency range.

This system was first applied to open-wire telephone circuits where large conductors with relatively low loss were available. In the last 6 years it has been applied extensively to telephone cables consisting of small gauge wires (19 gauge) insulated with paper, twisted in pairs and closely packed together in a lead sheath. The standard system for such telephone cables stacks 12 conversations on 2 pairs—one for each direction of transmission. Each channel requires a transmission band of 4000 cycles, and the total occupies a band from 12,000 to 60,000 cycles. These transmission bands are in current use on a great network of cable routes all over the country and similar bands with a somewhat different frequency allocation are used on open-wire lines.

Placing still more channels on one pair would mean using still higher frequencies. As the upper limit of the frequency range is raised, the difficulties of providing suitable transmission paths become increasingly formidable. One major difficulty arises from the necessity of reducing to truly microscopic proportions the transfer of energy from one pair of wires in a cable to any other. With 100 or more pairs of wires packed tightly together, this is a great task even at frequencies up to 60,000 cycles, and it becomes progressively more difficult the higher the frequency range. While it is a matter of judgment just how far to go, it is evident that telephone pairs of a conventional design are not adapted to the transmission of very broad bands of frequencies over long distances.

For a solution of this problem, shielding is naturally indicated. But if we are to use a shielded conductor, the logical thing is to start afresh, ignore the traditional form of telephone cable and design a conductor suited for the transmission of very high frequencies. Consideration of this problem leads naturally to a very simple and classical form of conductor—the coaxial unit consisting of a cylindrical conductor surrounded by a cylindrical shield which also acts as a return conductor. The space between the two is, as far as possible, air insulated to minimize losses at high frequencies.

This design of conductor was selected. Through a very extensive development process, means were worked out for building such conductors economically on a large scale and of such design that several could be grouped together under one lead sheath and used under practical conditions.

The width of frequency band which can be transmitted over such conductors is primarily a matter of the design possibilities of associated equipment. The equipment now in use with the coaxial system is capable of transmitting a frequency band up to about 3,000,000 cycles. With this equipment, we find it possible to transmit simultaneously 480 telephone conversations without mutual interference.

TELEVISION TRANSMISSION

The requirements for television transmission are, I believe, known to you through the activities of your television committee and other committees. As regards width of frequency band, the requirement may be roughly expressed as equivalent to sending an electrical impulse for each point of a half-tone picture and transmitting sufficient frames per second to avoid undue flicker or irregular movement. The present standard for television calls for 525 lines, 30 frames per sec, and a frequency band of approximately 4,000,000 cycles. This is less definition than is provided by standard commercial motion pictures. Nevertheless, the band width of the present television channel is approximately 1000 times that of a telephone circuit. We have thus a confirmation of the old proverb, "A picture is worth a thousand words."

In some respects the transmission requirements for television are more severe, and in some respects they are less severe, than the requirements for multiplex telephony. In the present coaxial cable system the useful band of frequencies is somewhat greater when the system is used for television transmission than when it is used for

multiplex telephone transmission. This is in part because the noise limits are less severe and in part because with the single broad band of television, the requirements for avoiding interaction between various parts of the band are less severe than when the band is split up into many separate transmissions. In the latter case a very minute amount of interaction may cause interference between the separate transmissions. With the equipment now used on coaxial cable, a television band of 2.7 megacycles can be transmitted. While this shades the full requirements for the standard 525-line transmission, tests indicate that satisfactory results are obtained with present television equipment. This was demonstrated in 1941 in a transmission over a distance of about 800 miles obtained by looping back

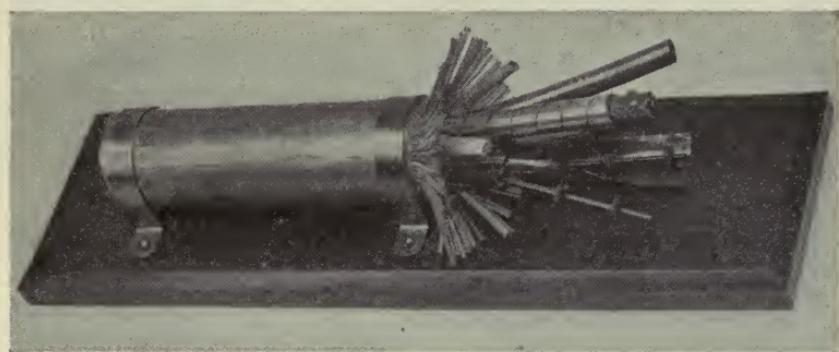


FIG. 1. Cable with 4 coaxial units and layer of 19-gauge quads.

and forth the coaxial units in a cable between Stevens Point, Wisconsin, and Minneapolis.

Development work which was started before the war and which is expected to be successfully concluded shortly after the war is over looks to improved equipment capable of transmitting a band of 7 megacycles or more. With this system, it will be possible to transmit a 4,000,000-cycle band for television plus 480 telephone channels simultaneously over the same conductors, or to transmit a broader television band if the standards of television should be so raised as to require it.

TECHNICAL FEATURES OF THE COAXIAL CABLE SYSTEM

Some of the more interesting technical features of the coaxial cable system can best be indicated by reference to a few figures. The

cable itself is made up as indicated by Fig. 1. Generally speaking, a number of coaxial units and a number of ordinary paper-insulated paired conductors are included together under the same lead sheath, the number of each being determined by the expected future service requirements to be taken care of by the cable over a number of years.

At the present time, these cables are generally placed underground by the use of a plow-train as indicated in Fig. 2. Three caterpillar tractors connected in tandem are followed by a rooter plow which prepares the ground for the cable, then by a fourth tractor backed by the cable-laying plow, and finally by one or more reels of cable. This



FIG. 2. Plow-train burying cable.

entire equipment is connected together as a single train and as it advances the cable is automatically fed off the reels through the plow and buried at a depth of 30 in. or more in the earth.

An essential element of the system is the amplifiers which are placed in the cable at distances of about 5 miles. One such amplifier is indicated in Fig. 3. It is a 3-stage amplifier giving 50 db amplification provided with negative feedback and so free of distortion that the currents of hundreds of different telephone channels covering a frequency band of 2 million cycles can be transmitted across the country without mutual interactions sufficient to cause any interference.

Fig. 4 shows the assembly of 2 amplifiers and auxiliary equipment

in a case suitable for connection into a pair of coaxial conductors at one point. The 2 amplifiers are the 2 black square boxes near the top of the case. Above them is automatic regulating equipment designed to counteract the variation in loss caused by variations in temperature of the cable. These regulators make a very interesting application of thermistors whose temperature is controlled by the flow of a pilot current over the circuit and which, by their variations of resistance with temperature, provide automatic compensation. The compensation at these repeater points is supplemented at main re-

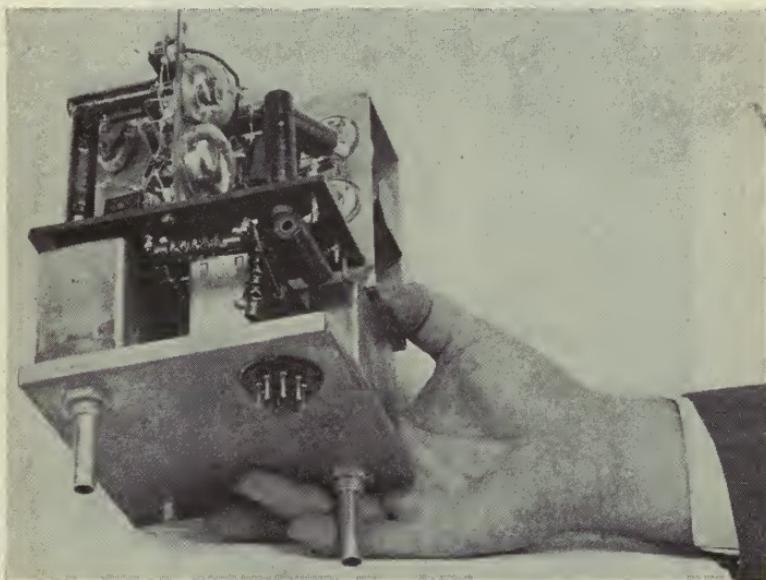


FIG. 3. Coaxial amplifier.

peater stations 50 to 80 miles apart by a supplementary over-all compensation controlled by pilot currents of 4 different frequencies which represent all parts of the frequency range.

A fundamental feature of the coaxial cable system from the standpoint of economics is that the cable is its own power transmission line. Power for the amplifiers is provided over the cables from main repeater stations, perhaps 80 miles apart. The equipment for taking off the necessary amount of power is indicated in the lower part of the panel shown in Fig. 4.

The various broad band carrier systems used by the Telephone Company all start with the standard arrangement of 12 channels packed into a frequency band of 48 kilocycles. The double modulation process by which this 12-channel group is assembled and located in the frequency range from 12 kilocycles to 60 kilocycles for transmission over paired cables is indicated in Fig. 5. The close packing

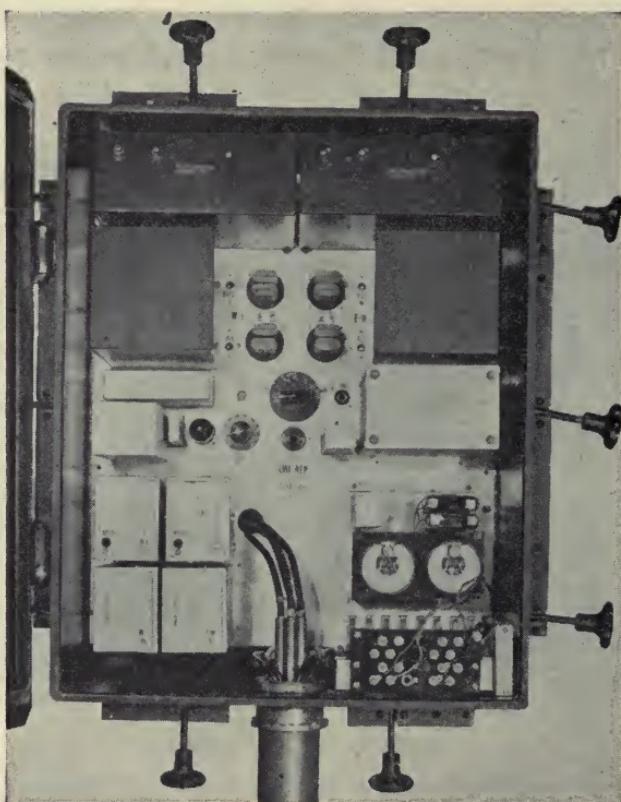


FIG. 4. Equipment at coaxial repeater station.

which this represents has involved great advances in the development of electrical filters, and this has been partly brought about by crystal elements. The modulation and demodulation are, to a large extent, done by varistors rather than by vacuum tubes.

For transmission over the coaxial cable, these 12-channel groups are further grouped as indicated in Fig. 6. A standard supergroup of 60 channels is created by closely packing 5 of the 12-channel groups

into a 240-kilocycle band. This supergroup is further translated into various parts of the frequency range, as indicated in the figure for transmission over the cable. The figure also indicates the frequencies of the 4 pilot channels used for automatic regulation.

For the transmission of video signals over the coaxial cable, it is necessary to raise the frequency band about 300 kilocycles, principally in order to reduce the problems of phase equalization which become very difficult for lower frequencies. The modulations by

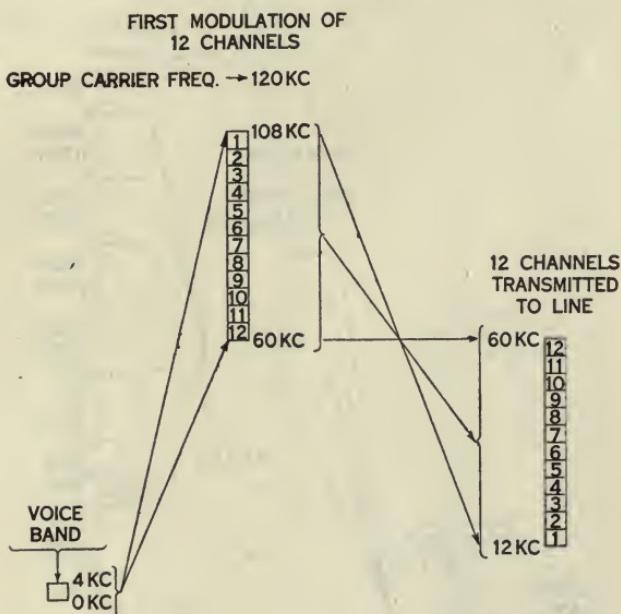


FIG. 5. Frequency translations in carrier telephone terminal equipment for paired-conductor cables.

which the video signal band is raised in frequency in the present form of equipment are shown in Fig. 7.

For operation of the system as a whole over long distance, a tremendous nicety of design is required. This has been achieved by a long development process which has brought out many fundamental features, only a few of which have been mentioned.

The economy in cables which results from the use of this development for heavy long-distance telephone routes is indicated in Fig. 8. The 6-unit coaxial cable shown at the top will transmit as many telephone conversations as the 2 paired cables shown below it when these

are fully equipped with 12-channel carrier systems, and also as many as the 4 large voice-frequency cables shown below, which represent the art of a few years ago. Development of the 7-megacycle repeater for coaxial will further increase its capacity.

PROGRAM OF THE BELL SYSTEM FOR THE CONSTRUCTION OF A COAXIAL CABLE NETWORK

While the coaxial cable system has been in service in this country for several years, its application up to the present has been limited be-

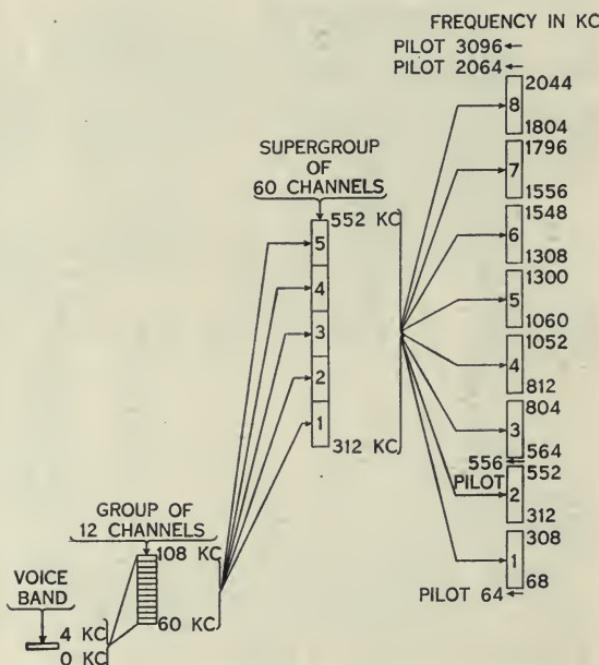


FIG. 6. Frequency translations in carrier telephone terminal equipment for coaxial cable.

cause of the war. A section of cable between Stevens Point, Wisconsin, and Minneapolis about 200 miles long has been in service since 1940. Cables have been placed between New York and Washington and are in service between New York and Philadelphia. Cables between Atlanta and Jacksonville and between Terre Haute and St. Louis are under construction.

The development had reached a point just before the war where we were prepared to go forward with its wide-scale use on heavy tele-

phone routes. The exigencies of the war, however, have delayed placing the equipment into production on the large scale which would be necessitated by such use. Recently, manufacturing preparation has been made for such production and it is expected to be well under way by the end of this year.

In order to guide the manufacturing preparations, a general study of the needs of the Telephone Companies for this type of cable in meet-

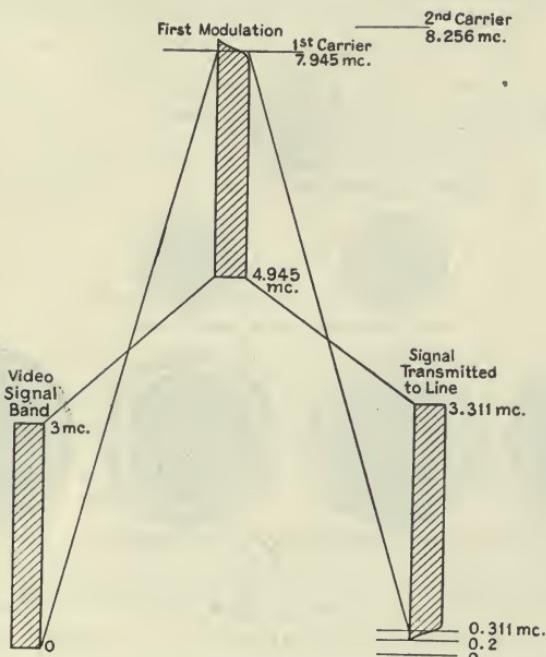


FIG. 7. Frequency translations in television terminal equipment for coaxial cable.

ing the requirements of their present forms of service was made early this year. This has led to a tentative program for the next 5 years which is shown in Fig. 9. One feature of the coaxial cable network so proposed, as you see, is a cable along the Atlantic Seaboard to Atlanta thence across the southern part of the country to Los Angeles and to San Francisco. Another main route will be from the Eastern Seaboard route west to Chicago and St. Louis with a connecting link south from St. Louis to New Orleans intersecting the main East-West route.

While, in detail, this plan will no doubt be modified as it progresses, we are building up manufacturing capacity to the levels necessary to carry out a plan of this size and expect that within about 5 years something substantially similar to this will be in operation.

The hurdle of placing this system in large-scale production having once been passed, it is not anticipated that the program will depend upon continuance or termination of the war. All through the war period it has been necessary to carry out a large program of construc-

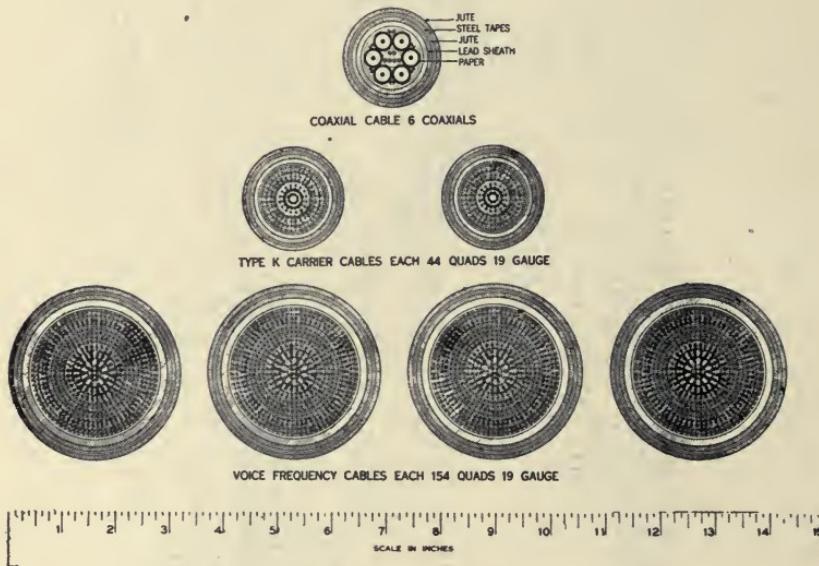


FIG. 8. Comparison of coaxial cable with other types providing same number of telephone circuits.

tion of long-distance circuits, although the amount of plant constructed is very much less than would have been built in peacetime to handle the same amount of traffic. This coaxial cable program, therefore, does not constitute an added burden, and from the point of view of long-term requirements, it is the method involving the least use of men and materials for meeting the telephone requirements of the nation.

It is obvious that such a coaxial cable network will form an excellent beginning for the development of nation-wide television transmission networks, if the development of the art is such that these be-

come desirable. It is necessary to include in the cables a sufficient number of units to take care of expected growth over a number of years. By the use of these conductors provided for future telephone growth, a limited number of television circuits can be established in the cables initially without interfering with telephone requirements. Future technical developments will further increase the capacity of the cables both for telephone and for television transmissions. The cables can be designed with a sufficient number of units to take care of the total estimated requirements of all services over a period of years, taking these possibilities into account.

When this first program is completed, we expect to continue to place coaxial cables in other locations to meet the service requirements of the Bell System unless in the meantime, of course, some other better method of meeting these requirements should be developed.

TRANSMISSION WITHIN CITIES

So far we have been talking of transmissions over long distances between cities. You will be interested, no doubt, in a brief statement regarding the possibilities of obtaining television transmission circuits within urban areas, particularly circuits between studios and pickup points and between studios and television transmitters.

The Telephone Companies have a network of telephone cables under the streets of our cities. Very fortunately we have been able to develop a means for using ordinary telephone pairs in these cables over moderate distances for television transmission. Today, this requires adjustments and the installation of amplifiers and equalizers spaced at approximately one-mile intervals.

For distances more than a few miles, coaxial units or special shielded pairs have advantages. This is particularly true when the cost of providing such special conductors can be reduced by including them together with ordinary telephone conductors in cables placed to meet the general telephone requirements.

For some time we have been providing circuits both on ordinary telephone pairs and on special shielded conductors between studio and transmitter, and between studio and pickup point. Our experience with these circuits has been successful and there seems to be no question that the Telephone Companies, on reasonable notice, can provide circuits of this sort as they may be required.

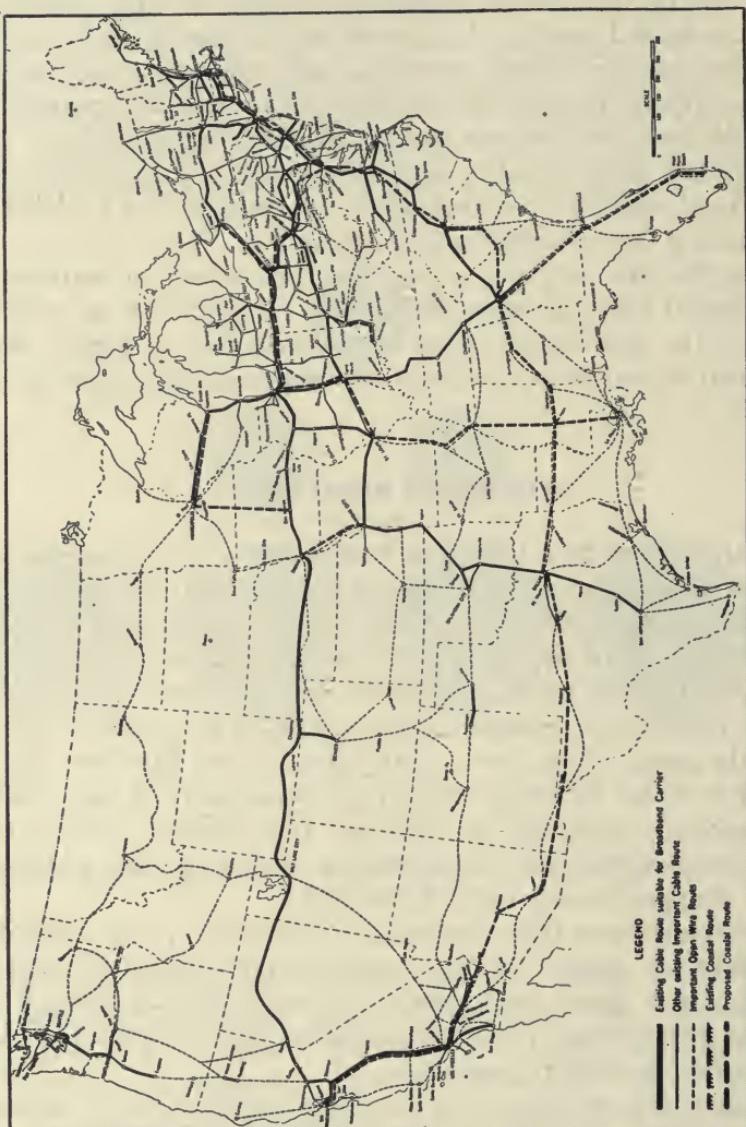


FIG. 9. Routes of present broad-band cable systems, important open-wire lines, and contemplated new coaxial cables.

FUTURE DEVELOPMENT POSSIBILITIES

Looking ahead, what other methods of transmission may be developed which are suitable for the very heavy traffic routes of the nation?

I have already pointed out that the completion of the 7-megacycle system for coaxial cables will not exhaust the inherent possibilities of such cables. It is possible that the wonderful advance in the technique of design of equipment for high frequencies which has already been made and other advances to be made in the future, will lead to a further broadening of the transmission band on these cables and hence to a further increase in their capacities. Whether or not this transpires, the future alone can determine.

What then of our alternative plans? Of course, the leading alternative at the present time is the microwave radio system. You may have noticed the announcement made some time ago that the Bell System has already made arrangements for a development trial of such a system between New York and Boston. If this system succeeds it will, for the time being at least, form the New York-Boston link of the network indicated on Fig. 9.

The Federal Communications Commission has approved our application for permission to build and experiment with such a system, and work will proceed just as soon as the relaxation of war demands makes this possible. For this trial, 7 intermediate relay repeater points will be used. The Federal Communications Commission has assigned to these experiments frequencies of about 2000 megacycles, 4000 megacycles, and 12,000 megacycles. This trial will be used as a method of determining practically the possibilities of this type of system in the present stage of development or, more exactly, in the state of development which can be brought about soon with intensive additional work. What the outcome will be no one can say. We all look, however, with admiration and amazement at the great strides which have been made during the war in the development of apparatus using these ultra-high frequencies, and I think have little doubt that in the long run such a system will be made practicable. What its proper field of use will be in competition with other methods of transmission is, of course, as yet to be determined.

If the radio beams are found to have undesirable characteristics, an alternative method of using ultra-high frequency is through the use of wave guides. These are simply hollow pipes which serve to isolate a little section of the space and thus guide the transmission of ex-

tremely high-frequency waves, and also protect them from outside interferences. Such wave guides are now extensively used for short distances in ultra-high frequency work. Whether such wave guides will have a field for interurban transmission in competition with coaxial or repeatered radio remains for the future to determine.

CONCLUSION

I pointed out that the Bell System Companies expect to have in a few years a very considerable network of coaxial cable suitable for television transmission. Over the years the Telephone Companies expect to continue to build on their major routes plant suitable for broad-band transmission either by coaxial cable, by radio relay systems, or any other system which proves to be advantageous. At the present time the coaxial cables are being placed only on routes where they are required to meet the prospective needs of the present services of the Telephone Companies. Also, the number of television transmissions which can be provided on such routes by the use of spare facilities, and by the increased capacity resulting from future development, will be somewhat limited until specific provision can be made in building the routes for the future demands of the television industry. There is, of course, economy in concentrating television and telephone requirements along the same routes and in the same structures as far as practicable, whether such routes be of coaxial cable or of microwave radio relay. We should like to take full advantage of such concentration so that we may serve the television industry as well and as economically as possible. The telephone people therefore welcome, from all who are interested in the application of this new art, information as to the development of their requirements, so that telephone engineers can recognize these new service requirements in their advance planning.

THE DENSITOMETRY OF MODERN REVERSIBLE COLOR FILM*

MONROE H. SWEET**

Summary.—Sensitometric procedures for modern multilayer reversible color films are much more exacting than those for black-and-white films. The tolerances for exposing and processing these materials are smaller and the analysis of the results is more difficult.

The problem of evaluating the processed sensitometric strips in terms of the color densities of each step has been facilitated by the construction of a specialized form of a direct-reading densitometer. An electron multiplier phototube, coupled to the grid of a logarithmically responsive triode, furnished the extreme sensitivity necessary to read high color densities with satisfactory spectral purity.

Modern Reversible Color Film.—In the past few years, manufacturers of photographic products have developed reversible color films which yield positive transparent images capable of reproducing practically the entire gamut of colors found in everyday life.^{1,2} These materials are called multilayer color films and, after processing, form 3 superimposed dye images. The dyes used are cyan (minus red), magenta (minus green), and yellow (minus blue). To maintain control of product quality and to determine, quantitatively, the effect of different illumination and processing conditions, routine sensitometric tests are conducted in a manner which is especially adapted for evaluating the photographic characteristics of color materials. This paper is chiefly concerned with the densitometry of the processed sensitometric strips.

General Sensitometric Technique for Reversible Color Film.—In black-and-white photography the measurement of the speed, gradation, and fog of the emulsion is the principal object of ordinary sensitometric studies but the accuracy demanded is relatively low and for practical use speeds may be figured in half stops. Reversible color film, on the other hand, necessitates much closer control of the

* Presented Oct. 17, 1944, at the Technical Conference in New York.

** Research Laboratories, Ansco, Binghamton, N. Y.

sensitometric variables—lighting, exposure, and development—than black and white and, since the original image is the one intended for viewing, ordinarily no correction is afforded through printing.

Color sensitometry, like black and white, may be classified in 4 steps:

- (1) Exposure.
- (2) Processing.
- (3) Density evaluation.
- (4) Interpretation of results.

In the Ansco Color Laboratories, routine tests of production samples of Ansco Color Film are made by exposing strips on an intensity-scale sensitometer whose source-filter combination has been adjusted to duplicate practice. Processing is, of course, rigidly controlled to conform with standardized techniques. The processed sensitometer strips are analyzed on a special photoelectric densitometer adapted to read color densities in 3 spectral regions and these results may be used directly, or they may be converted into equivalent densities. By comparing the color density versus $\log E$ curves with similar curves for materials known to give optimum results in practice, it is possible to determine what adjustment, if any, should be made in the final product for best color rendition.

Color sensitometry has been discussed in the literature in greater detail than that warranted in this paper and the reader is directed to the references for discussions of the many factors involved.

General Aspects of Density Measurement.—In general, optical density is defined as the common logarithm of the reciprocal of the transmission, $D = \log_{10} 1/T$. However, for practical specimens the numerical result will vary according to the mode of illumination and collection (the geometry of the system) and also according to the spectral character of the light source, specimen, and receiver. For most black-and-white photographic work wherein prints are to be made from negatives, experience has shown that diffuse printing density is suitable as a reference standard.³

The densitometry of reversible color film, on the other hand, is somewhat more complex owing chiefly to the spectral character of the specimen. Given a color film patch of uniform color the problem arises of how to define the density of the pack as a whole and of each layer separately from the spectral standpoint. Fig. 1 shows the density versus wavelength relationship for each layer of a sample

which appears gray under ordinary viewing conditions. Also shown is a curve representing the integral spectral density* of the 3 layers.

It will be noted that the magenta and cyan layers contribute significant amounts of blue density although they are nominally transparent in this region of the spectrum. For specimens which are visually gray** it is appropriate to use simply visual density (with an incandescent light source) as the criterion of absorption in the reversible process. However, for off-gray samples the concept of visual density is difficult to apply and, therefore, the characteristics of the 3 layers have to be expressed separately. Heymer and

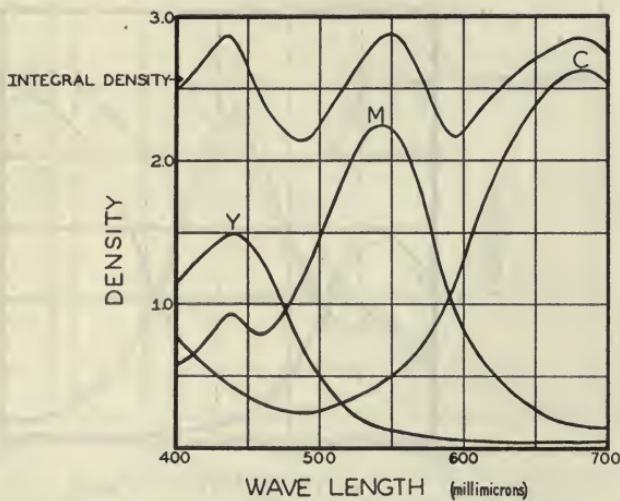


FIG. 1. Density versus wavelength relationship for a 3-layer color film.

Sundhoff⁴ proposed "grauequivalente Farbdichte" (gray equivalent color density) which Evans⁵ called simply "equivalent density" and defined as *the visual gray density of a single layer of an off-gray sample to which sufficient density of the two other layers of the process is added or subtracted so as to produce a visual gray result*. Thus the gray specimen whose spectral characteristics are represented in Fig. 1 has

* By "integral spectral density" we mean the total density of the 3-layer specimen at the wavelength in question.

** A distinction should be made between the terms "gray" and "neutral." A "neutral specimen" is one which is completely nonselective in its spectral absorption characteristics. A "gray specimen" is one which gives the same visual impression as that of a neutral sample.

equivalent densities of 2.5 for all 3 layers. In Fig. 2 a specimen deficient in its cyan dye is shown. This specimen has the same equivalent densities for its magenta and yellow layers as that shown in Fig. 1. The equivalent density of the cyan layer, however, is only 2.2, for when sufficient density is subtracted from the magenta and yellow layers to give a gray result (as represented by the broken lines) the visual gray density of the pack is found to be 2.2. It will be observed that

- (1) Because of "spectral impurities" in practical color film dyes

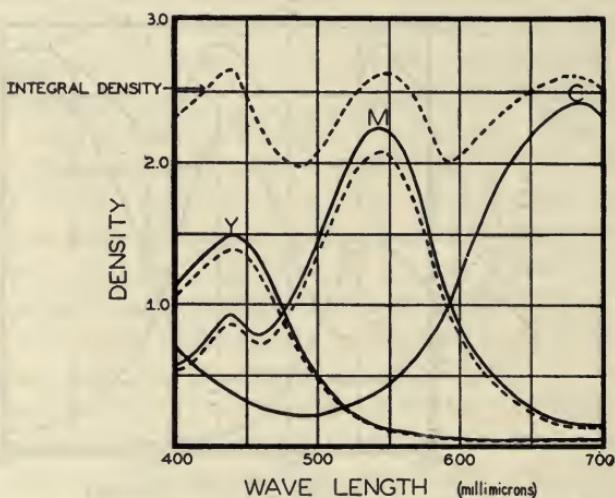


FIG. 2. Density versus wavelength relationship for a cyan deficient specimen. (Broken lines indicate the characteristics of magenta and yellow dyes whose concentrations are adjusted to give gray.)

the equivalent density of a given layer of a given sample will always be considerably higher than its maximum spectral density. (This statement would not apply to processes wherein the dyes were ideal and were mutually complementary.)

(2) The ratio between the spectral densities of any 2 dye images at any wavelength is constant when the dyes are present in such concentrations as to produce gray.

Evans has shown that by constructing a visual densitometer in which controllable amounts of the 3 dyes may be introduced into the photometric beam the equivalent density of each layer may be evaluated. It will be apparent that if in off-gray samples the exact

amounts of the complementary dyes necessary to produce gray were known, the equivalent densities can be evaluated directly. (See Fig. 2.) In this way, sensitometer strips in which the 3 dyes are always present can be evaluated, layer by layer, as though the 2 complementary layers were not present, and the behavior of the individual layers can be studied. The 3 sets of equivalent density values can be plotted against $\log E$ and the results checked against those obtained for samples known to be in satisfactory color balance.

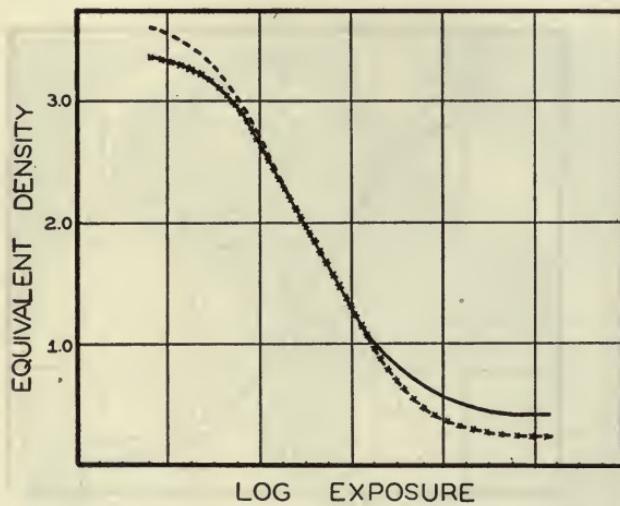


FIG. 3. Equivalent density versus log exposure for an off-balance material which has a magenta-colored maximum density, neutral middle tones, and a yellowish toe.
— Yellow layer; - - - Magenta layer; x x x Cyan layer.

Fig. 3 shows the equivalent density versus $\log E$ curves for a sample having a magenta-colored maximum density, gray middle tones, and a yellow toe. A sample which faithfully reproduces gray at all density levels will, by definition, have identical equivalent density versus $\log E$ curves for all 3 layers. However, it should not be inferred that emulsions which faithfully reproduce gray are necessarily superior in all respects to others which do not. Gradiation, color contrast, saturation, and other factors are also involved.

R. Bingham and H. Hoerlin, of this laboratory, have shown* that

* Private communications—to be published.

it is possible to evaluate a specimen in terms of its equivalent densities from the integral spectral densities measured at 3 different wavelengths, if the ratios of the densities of the dye components at each of the wavelengths are known. It can be readily understood that for every different combination of densities of the 3 dyes there will be a unique set of 3 integral density readings and a corresponding set of equivalent density values. Those familiar with masking processes may grasp the principles involved, in fact, the 3 equations (all linear) which show the relationship between the equivalent density and the

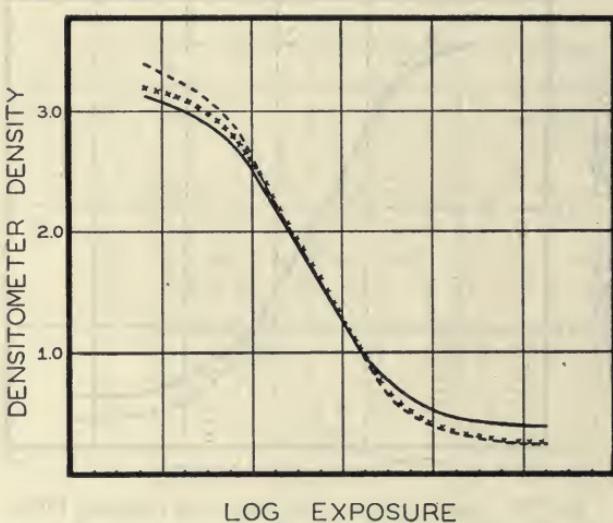


FIG. 4. Densitometer density versus log exposure for the same sample as that represented in Fig. 3. — Blue reading; - - - Green reading; x x x Red reading.

integral density readings are identical with those used in connection with the automatic masking technique in subtractive color processes and have been given in the literature.⁶

Integral density readings made at the 3 wavelengths corresponding to the maximum absorption of the dyes also give useful information directly and can be interpreted to some extent without resort to supplementary computation. This is particularly true after some experience is gained in analysis of these values. By direct comparison of curves plotted from the density readings for a test specimen with similar curves for samples known to be in perfect color balance, qualitative interpretation of the results is possible. The comparison of these curves is further facilitated if the 3 wavelengths chosen for

the measurements are such that the integral spectral densities are equal for gray specimens. Then the three D versus $\log E$ curves will be superimposed for strips which are in perfect color balance.

Figs. 3 and 4 show a comparison between equivalent density and densitometer (integral) density versus $\log E$ values for one and the same off-balance sample.

General Requirements of a Color Densitometer.—From the above discussion it is apparent that a satisfactory method for density evaluation is important in cases where large numbers of sensitometer



FIG. 5. Direct-reading densitometer manufactured by AnSCO (Model 11).

strips are handled. In contemplating the general requirements for a suitable color densitometer the following comments are pertinent:

(1) The instrument should be objective and direct reading. This not only eliminates visual fatigue and error, but also introduces the possibility of attaching a recorder where such is warranted.

(2) For simplicity of design the instrument should read the integral spectral density of the specimen at each of the 3 wavelengths. Although it would be desirable in many respects to design the instrument to read equivalent densities, directly or by a null point balance arrangement (the photoelectric counterpart of Evans' densitometer), a number of inherent design complications and phototube deficiencies made it advisable to choose the simpler direct-reading color densitometer which gives the integral density values at 3 wavelengths at or near the absorption maxima of the 3 dyes of the process.

(3) The density range should be at least 0-3 for all colors.

(4) Spectral purity of the optical components of the densitometer should be commensurate with the character of the dyes to be analyzed. If the "monochromatic" filters have too broad a wavelength transmission band, the effective sensitivity of the instrument to small differences in the concentrations of the dye images will be reduced, and it will also make the subsequent calculation of equivalent density values inaccurate or extremely complex.

(5) Many other obvious factors such as stability, reproducibility, speed of response, etc., should fall within satisfactory limits. Most of these factors are common to black-and-white densitometers and have been discussed in the literature.⁷

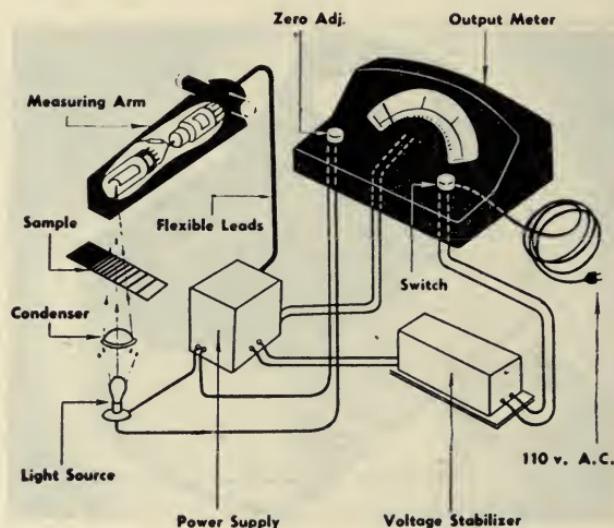


FIG. 6. Phantom view of the Ansco Model 11 densitometer.

Suitability of Existing Densitometers.—After it was agreed that a densitometer of the type indicated by the above requirements was needed, the possibility of using a previously developed black-and-white instrument was examined. A simple direct-reading photoelectric instrument had been designed and proved reliable,⁷ and it seemed possible to modify this instrument for reading color densities. The commercial model of the instrument is shown in Fig. 5. Fig. 6 is a phantom view of the operating components. Light from a 15-cp automobile headlamp is focused on a small aperture and collected by a phototube. The phototube current is fed into the grid circuit of a triode and the plate current is measured directly on a 1.0-ma d-c output meter. A circuit diagram is shown in Fig. 7. Because the

relationship between grid current and plate current is logarithmic, the output meter response is uniform for uniform changes in the density of the specimen over a wide range of density values.

In its commercial form this instrument is too insensitive to meet requirements (3) and (4) simultaneously. Furthermore, it is not provided with filter holders for easy and rapid interchange of filter sets. By replacing the 15-cp light source with a projection lamp of higher candlepower and collecting a greater solid angle of flux, fairly pure monochromatic filters may be used, and a density range of 0-3 can still be covered.⁸ However, the deficiency in relative red sensitivity of the type S-4 photosurface used in the instrument is just

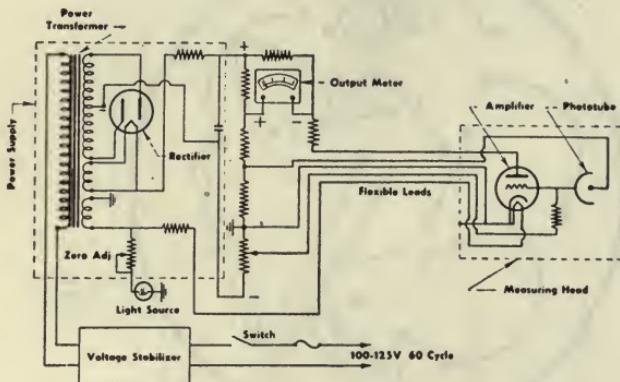


Fig. 7. Circuit diagram of AnSCO Model 11 densitometer.

enough to necessitate resort to a more sensitive amplifier circuit because a spectrally pure red filter reading is required for the present application.

The electrostatically focused electron multiplier phototube⁹ provides a receiver having a net photosensitivity of the order of 10^4 times as great as that for the common type of phototube used in the commercial instrument.

A representative 9-stage multiplier phototube is the type 931, illustrated diagrammatically in Fig. 8. Light striking the photocathode liberates electrons. Assuming one electron to be liberated by the action of the light on the photosurface, it is attracted to the first dynode—a cup-shaped plate held at a positive potential with respect to the photosurface. When the electron strikes the dynode two or more secondary electrons are released. These electrons are

attracted to a second dynode which is held at a still higher positive potential. The multiplying action is accomplished in this manner and in 9 dynode stages the amplification factor may be made as high as 200,000. However, direct coupling of such a tube to the high impedance grid circuit of the logarithmic amplifier used in the original densitometer presented some difficulties, principally because polarity relationships demand that the entire power supply must be connected to the 6F5 grid and must also be shielded and insulated to an extent which is comparable in impedance with the (1000 megohm)

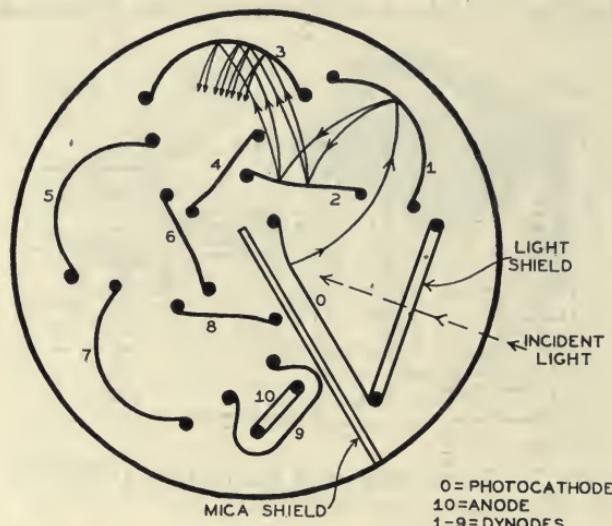


FIG. 8. Explanatory diagram showing the action of an electron multiplier phototube.

grid bias resistor. Obviously, no ordinary a-c supplied power pack would meet these requirements. Furthermore, stability of the output voltage would be entirely inadequate unless special circuit precautions were observed.

By connecting 10 miniature $67\frac{1}{2}$ -v batteries in series, a compact power supply is obtained which provides the necessary number of voltage taps as well as the high (700 v) voltage necessary for efficient operation of the multiplier tube. The entire pack measures only $4 \times 5 \times 7$ in. With this pack it is relatively easy to meet the shielding and insulation requirements demanded by coupling to the basic grid circuit. The voltage stability of the battery pack is far better than that required, largely because the current drain is in-

finitesimal for all except the last stage. The last stage operates at $30 \mu\text{a}$ maximum current (at zero density), and even this current is negligible in comparison with the load for which the battery was designed. When used in this manner the life of the pack is therefore equal to the shelf life of the batteries and with continuous daily use a given set of batteries will serve for well over a year before the terminal voltage drops prohibitively.

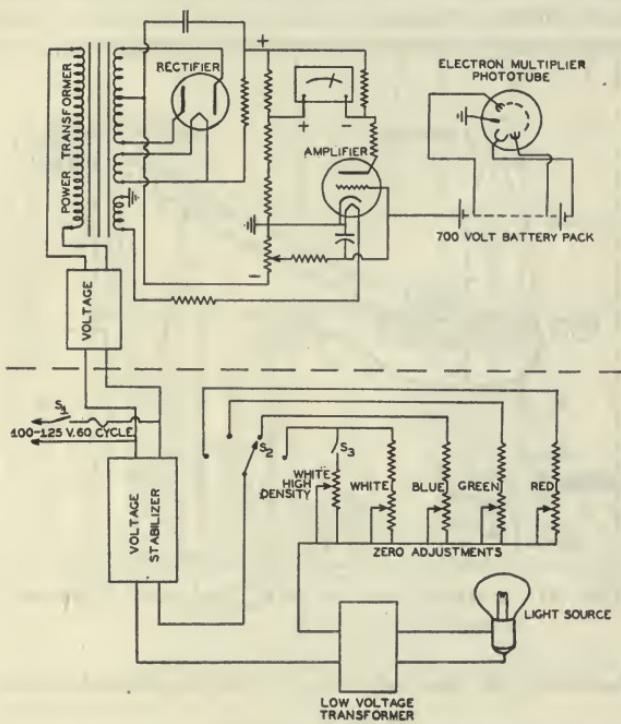


FIG. 9. Diagram of the complete electronic circuit.

However, 3 troublesome factors accompany the use of the multiplier phototube in this application:

- (1) The dark current of the majority of commercial multiplier phototubes is appreciable in terms of the operation of the triode amplifier stage. Since a density range of 0-3 is to be covered, this means that the ratio of multiplier tube output currents must cover a range of 1000 to 1. Since it is difficult to operate small triodes in the desired logarithmic manner at grid currents in excess of $50 \mu\text{a}$, and since the red sensitivity of available multiplier phototubes is low (and the maximum output for the red filter readings will be correspondingly low), the

grid current for a density reading of 3.0 will be of the order of magnitude of 0.05 μ A and dark currents greater than about 0.01 μ A cannot be tolerated. Difficulties owing to excessive dark current may be avoided by careful selection of multiplier phototubes.

(2) At this writing there are no multiplier phototubes commercially available in photosurfaces which have high sensitivity throughout the visible spectrum.

The best compromise was found to be the type 931 tube which has a caesium-antimony (*S-4*) surface characterized by high blue-green sensitivity and relatively very low red sensitivity. As a result it is necessary to alter the optical system in order to obtain the maximum possible red energy for the red filter reading. There is a very large individual variation in the far red sensitivity of photoelements having a caesium-antimony photosurface and by choosing a tube which not only

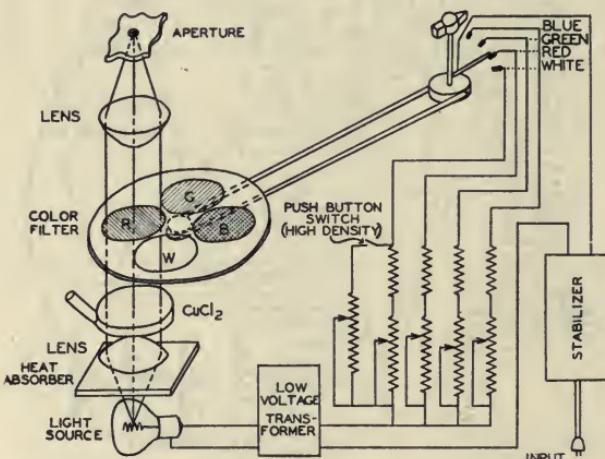


FIG. 10. Pictorial view of the optical control system.

has low dark current but also high red sensitivity the second difficulty may be minimized.

(3) The high gain associated with the multiplier tube, together with the extensive physical area of elements (battery pack and multiplier tube leads) connected in the triode grid circuit forms a system which has a strong tendency to oscillate, particularly at low levels of illumination wherein the net grid-ground impedance is high. Oscillation may be avoided by proper shielding alone, although it is also helpful to insert a grid bias by-pass condenser of about 0.001 μ F to act as a suppressor. (Higher capacitance values would cause sluggish meter response at high density levels wherein the grid to cathode d-c impedance is high.) No additional changes in the circuit were necessary. A wiring diagram of the complete circuit is shown in Fig. 9.

A 50-cp lamp energized by a separate stabilizer and low voltage transformer served as the light source. A filter disk holding 3 sets of

gelatin filters was mounted on a shaft. The shaft of an electrical tap switch was coupled with the filter disk in such a manner that as each filter was brought into the beam, a different variable resistor was connected in series with the primary of the light-source transformer so that once all 3 resistors are properly set changing from filter to filter will not necessitate readjustment of the zero setting. This has the additional advantage of preventing accidental overload of the grid circuit. By using fixed resistors in series with the rheo-

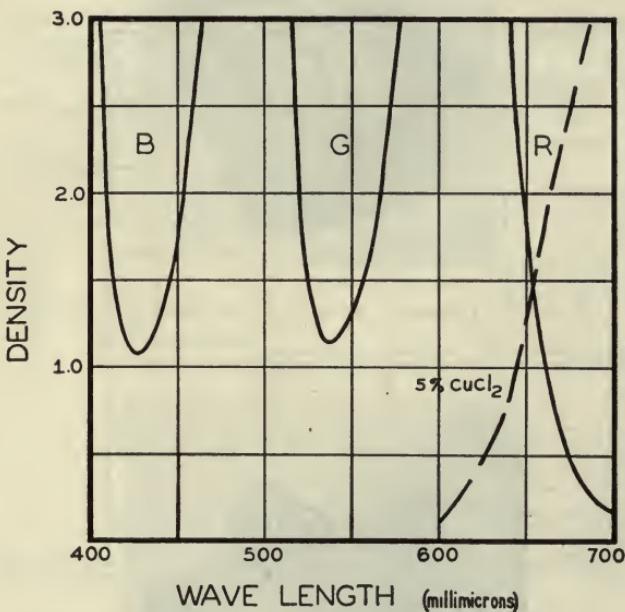


FIG. 11. Density versus wavelength curves for the monochromatic filter combinations used in the color densitometer.

stats, it becomes possible to effect a relatively fine adjustment of the zero setting and also to avoid the possibility of accidentally closing the lamp circuit completely and thereby increasing the lamp intensity beyond safe limits. A pictorial diagram of the optical control system is given in Fig. 10.

The selection of the blue and green filters was not difficult. The high sensitivity of the instrument in these spectral regions permitted the use of dense color filters in order to obtain sharp cutting monochromats which have their peak transmission at the desired wavelengths. It was found that Wratten filters 36, 2A, and 38A used in

combination were satisfactory for the blue, and Wratten 62 and 16 for the green. Their density-wavelength curves are illustrated in Fig. 11.

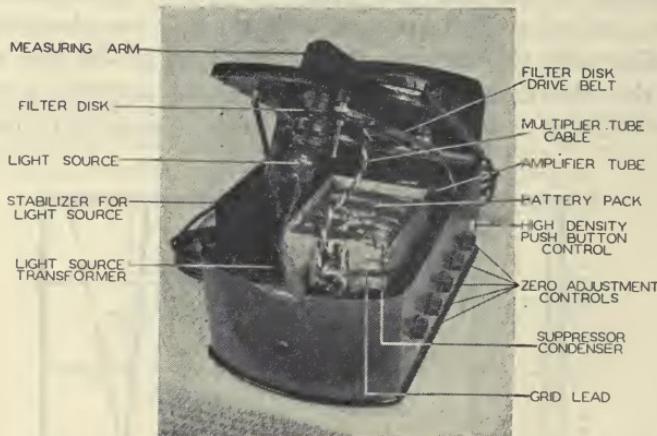


FIG. 12. Interior view of the color densitometer.

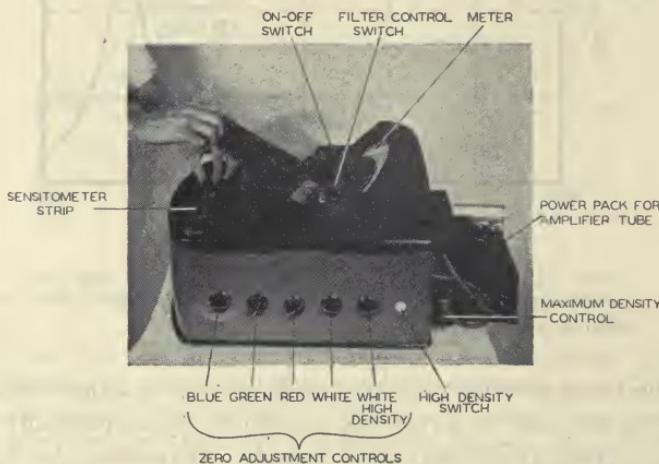


FIG. 13. Color densitometer in routine use.

The selection of filters for the red reading presented a problem. This is partly because no efficient sharp cutting infrared absorber with a cutoff at about $660 \text{ m}\mu$ is available. The best compromise was found to be the cupric chloride solution used in the maximum concentration tolerable in view of the light intensity available and

the sensitivity of the photoelectronic system. A Wratten 70 and 16 filter combination was used to absorb the short wavelength radiation for this reading. It was found that the temperature coefficient of spectral density of the cupric chloride filter was very high—so high, in fact, that it changed the spectral purity of the red readings by a significant amount when heated only 10°C above room temperature. By inserting a Jena BG19 heat-absorbing filter between the light source and the cupric chloride solution this effect is minimized.

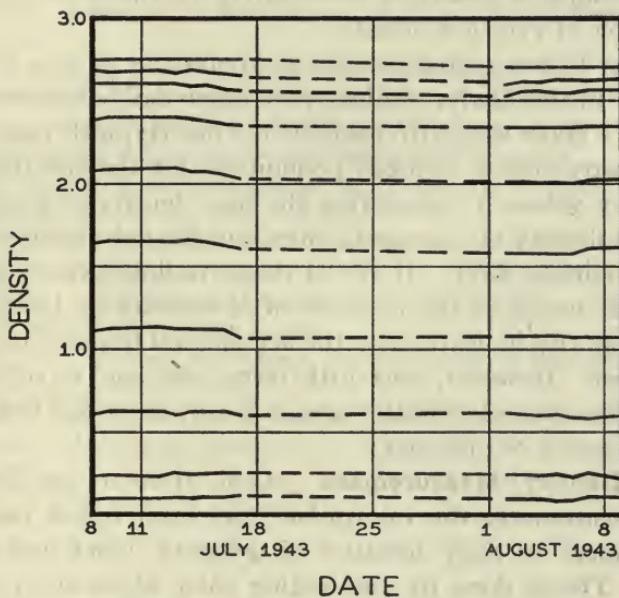


FIG. 14. Density readings for a reference standard strip made at intervals of one day.

Fig. 12 shows the interior of the instrument case. The case itself is electrostatically shielded and contains the battery pack (in an additional shield), light-source control resistors, and the optical system. The standard power pack for the logarithmic amplifier is mounted on the rear of the case and a separate voltage stabilizer for the light source is mounted on the other side.

Fig. 13 shows the instrument in routine use. The control knob at the right-hand side of the output meter is used to rotate the filter disk and insert the proper resistors in the light-source control circuit.

Calibration.—It has been found experimentally that the photocurrent response as a function of illumination of the type S-4 photo-

surface is nearly linear over a wide range of flux density levels and is not altered significantly for radiation at different wavelengths. The instrument was therefore calibrated, empirically, using the blue filter readings of a standard photographic silver wedge.

Performance.—From an over-all standpoint, the instrument performed satisfactorily in routine daily use. The zero reading stability was within acceptable limits although the inherent fatigue effects of the present-day multiplier phototubes are detectable when a dense sample is measured immediately following the measurement of a sample of very low density.

The day-to-day reproducibility is satisfactory as may be seen from Fig. 14. In this figure, readings were taken daily at different density levels for a given wedge over a period of one (typical) month.

The instrument is checked periodically for the spectral purity of its density values by measuring the blue density of a yellow filter, the green density of a magenta filter, and the red density of an infrared transmitting filter. If any of these readings depart significantly from their norm, in the presence of a satisfactory black-and-white calibration, this indicates that the net spectral response of the system has shifted. However, since little ultraviolet, and no infrared radiation reaches the gelatin filter sets, it is expected that this effect will not be a source of difficulty.

High-Density Measurement.—Aside from its application as a color densitometer the instrument has been found useful in the measurement of high densities of ordinary black-and-white materials. This is done by eliminating color filters from the optical system and using a momentary-close push button switch which inserts a low resistance shunt across the normal black-and-white resistor shown in Fig. 10. When properly adjusted, a specimen of density 3.0 will read 0.0 with the switch depressed and a specimen of density 6.0 will read 3.0. By increasing the lamp voltage still further, the instrument can be used to read densities up to 7.3. The sensitivity of the instrument to luminous flux is such that a density reading of 3.0 corresponds to 0.01 microlumen.

Summary.—The general aspects of color sensitometry have been discussed particularly with reference to the densitometry of modern reversible color film. Several requirements for a satisfactory color densitometer were developed.

Although more complex than the basic densitometer from which it was derived, the multiplier tube instrument satisfies these require-

ments fairly well. When properly constructed and handled, it is capable of giving reliable readings of color densities, rapidly and with good colorimetric purity. The results may be used directly or they may be re-evaluated in terms of equivalent densities.

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THE ART REEVES REFLEX MOTION PICTURE CAMERA*

ART REEVES**

Summary.—This paper describes a light, compact motion picture camera with a built-in finder system and other special requirements for military usage. These cameras are not available to the general professional trade at the present time. However, the application of experience gained in field usage by the Armed Forces will result in refinement of design and mechanical improvement in the post-war models.

This latest addition to the extensive line of Art Reeves motion picture equipment was designed to meet the need for a light, compact motion picture camera. It embodies the accepted features of professional cameras currently in production use and has, in addition, a built-in finder system with which the scene being photographed can be viewed through the taking lens in exactly the same form as the film is receiving it.

Emphasis in the design of the camera and its associated equipment has been placed on simplicity and ease of operation. Full consideration has also been given to the exacting requirements of military usage. The camera box, of anodized aluminum, meets government specifications relative to corrosion resistance. The moving parts of the camera will function perfectly after hours of exposure to temperatures as low as -70 F or as high as 160 F.

Fig. 1 shows the position of the controls and the dials at the rear of the camera, within easy sight and reach of the operator.

Traveling across the figure from left to right we see the eyepiece of the adjustable focusing microscope, marked 1, and the rear frame of the auxiliary finder, 2. Item 3 is the footage counter, with its knurled reset knob projecting slightly at the right of the dial. Item 4 is the variable shutter control and dial. The knob on the control arm is lifted to free it for movement. Item 5, the rectangular assembly at the right of the camera box, is the enclosed motor with its speed control knob and dial 6 and tachometer, 7. The knurled knob 8 permits

* Presented Oct. 18, 1944, at the Technical Conference in New York.

** Art Reeves Motion Picture Equipment Co., Hollywood.

the operator to turn the camera movement for threading purposes. The motor, in the illustration, operates from a 24-v battery and has a speed range from 16 to 48 frames per sec with intermediate positions at 24 and 32 frames per sec.

Speed is accurately maintained by a built-in governor which, in practical tests, has held the camera speed steady over voltage ranges

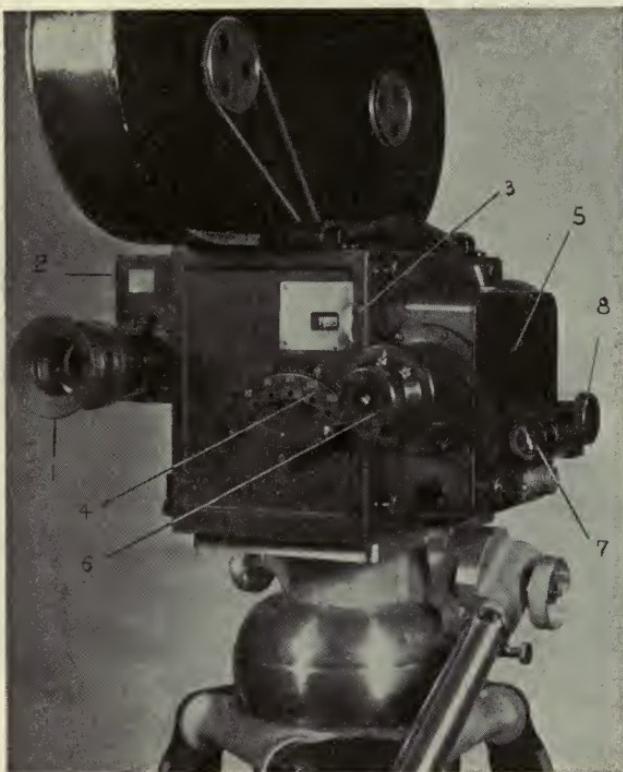


FIG. 1.

of ± 12 per cent from the standard 24 v. Motors for 12- and 110-v operation are available and interchangeable with that shown.

Also to be noted are the carrying strap on the top of the camera and the readily adjusted tripod handle on which the motor switch may be mounted for convenient operation.

Fig. 2 shows the camera from the threading side. At the left is seen the 3-lens turret which the operator, at the rear of the camera, can easily move from one position to another with one hand.

Item 1 is the built-in finder assembly on the side of the camera, terminating at the rear in the adjustable focusing microscope and eyepiece.

Above this assembly is seen the front and rear elements of the auxiliary finder which can be employed in emergencies or to give "anticipatory" borders. The eye position for this finder is just above that for the reflex finder.

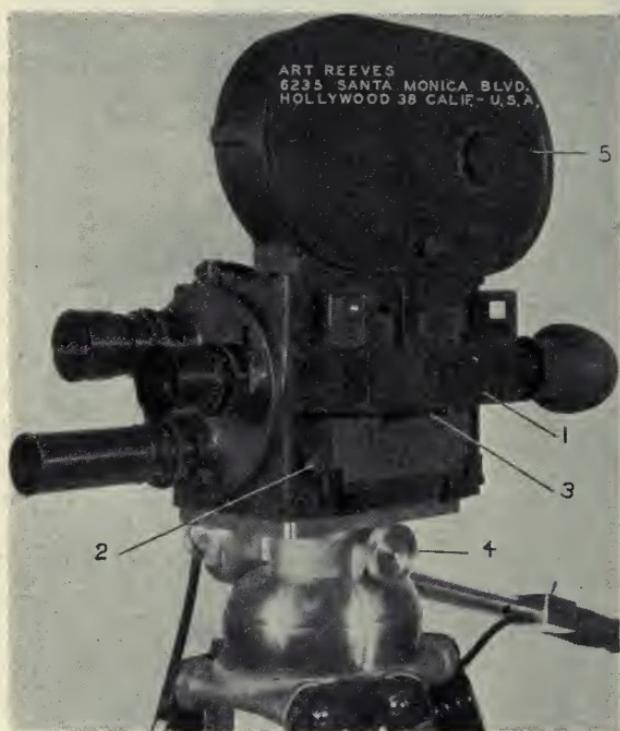


FIG. 2.

The door latch, seen above the finder assembly, is operated by depressing either of the small knurled knobs.

The knob 2 near the front of the camera controls the 2 positions of the reflecting element of the finder system, which will be discussed later.

Item 3, a lever on the under side of the finder assembly, controls a frame in which a viewing filter may be thrown in or out of the optical path.

The large knurled knob 4 operates the screw which locks the camera to the tripod base.

The magazine 5 of Art Reeves design has several unique features, in addition to being 25 per cent smaller and lighter than conventional magazines of similar capacity. The one-piece cover is secured by the 2 thumbscrews seen at the top and bottom. Loading operations, particularly under change bag conditions, are greatly facilitated by the simplicity of this arrangement.

On the take-up side, the film winds between 2 metal disks; the inner

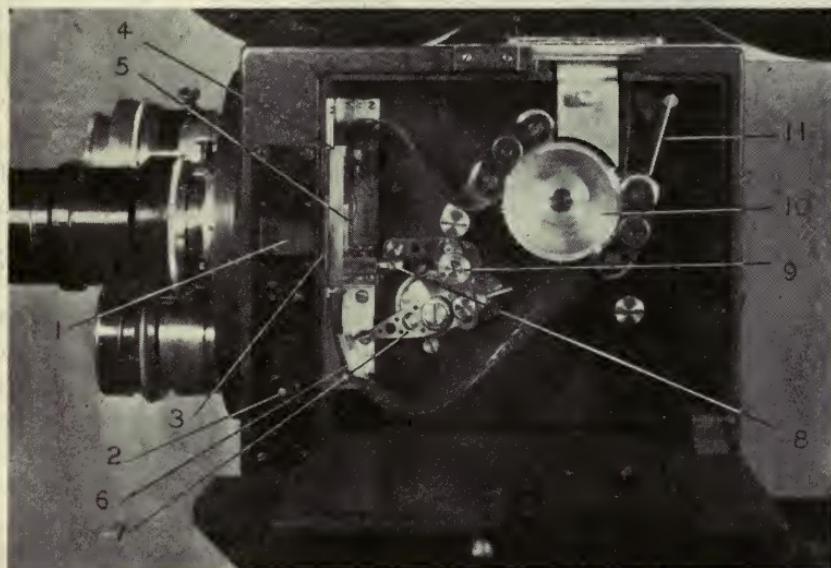


FIG. 3.

attached to the driven shaft, the outer to the magazine cover. The latter operates on ball bearings and is free to move with the film. The disks serve to align the film so that buckling from distorted rolls is avoided. The camera may be operated on its side or in any other position without danger from take-up failure owing to improper winding.

Mitchell and Art Reeves magazines may be used interchangeably. Cameras for use with Bell and Howell magazines are also available.

Fig. 3 shows the interior arrangement of the camera. At point 1 is seen an aperture containing a ground glass upon which is thrown the image viewed by the microscopic finder system. Behind the aperture is mounted a very thin, partially reflecting mirror which

diverts a portion of the light, entering through the taking lens, to the finder system and passes the balance to the film. The light-reflecting element can be placed in either one of 2 positions by vertical movement of thumbscrew marked 2. In one position, 50 per cent of the light is passed to the film, and in the other, 95 per cent. In both cases, the balance of the light goes to the finder system.

At point 3 provision is made for the insertion of inside filter holders.

Item 4 is the film gate assembly containing a removable pressure plate indicated by the figure 5. The gate is hinged on the inside and may be opened instantly for cleaning, inspection, or threading purposes. The removable pressure plate has 3 transverse fiber rollers in contact with the film.

Point 6 indicates the curved shoe through which the pull-down pin operates.

Items 7 and 8 are the pull-down and registration pin assemblies, respectively. The registration pin may be moved into its inoperative position by a turn of the thumbscrew 9.

The camera operates with the registration pin in either the operative or inoperative positions. Earlier models, without registration pins, gave satisfactorily steady pictures in field usage. It has been found definitely advantageous to be able to operate without registration pins under conditions of very low temperatures or in cases where old or shrunken film must be used. Side-rail tension applied in the film gate assists materially in maintaining good registration.

Item 10 is the conventional drive sprocket with its associated film retainer assemblies. The camera door cannot be closed unless the latter are in proper position.



FIG. 4.

Item 11 is a hinged, antibuckle plate which operates a motor cut-off in case of take-up failure.

Passing to Fig. 4, the camera (equipped with a Bell and Howell magazine) is shown mounted on the Art Reeves tripod. Weighing 24 lb, it is of the ball type with adjustable spring tension which can be employed to prevent tipping if the camera is operated in off-balance positions. Moving parts of the head operate against felt pads which prevent dirt and grit from causing wear and hindering operation. All tripod controls can be operated with light pressure. The Art Reeves tripod accommodates any of the standard professional cameras and, in turn, the Art Reeves camera fits any of the standard tripods.

An interesting accessory is available, however, which permits practically instantaneous locking and unlocking of the camera and tripod. Two plates are involved: one screws to the tripod head, using the camera locking screw, and the other is screwed to the base of the camera, using the locking screw hole. The tripod plate has, on its surface, a V-shaped open-ended recess which dovetails with a corresponding projection on the camera base. The camera, placed on the tripod, seats itself automatically in proper position when pushed forward. A spring catch snaps up behind the camera preventing accidental slippage backward. The dovetail of the 2 contacting elements prevents vertical movement.

To remove the camera from the tripod, the spring catch at the rear is first depressed with one hand while the other moves a short lever at the front of the base which, through an eccentric arrangement, exerts enough pressure to start the camera moving to the rear. The camera may then be lifted from the tripod. The rapid removal of the camera is of importance, particularly in aerial work, where it may be placed in doorways or restricted openings needed by the personnel in case of emergency.

Going back for a moment to the matter of lenses, all customary focal lengths may be used, down to and including the 35 mm. If it is desired to work with shorter focal lengths, an auxiliary lens of Art Reeves design is quickly attached, with thumbscrews, to one of the lenses already on the turret. The combination, for instance, of a 50-mm lens with the auxiliary gives the equivalent of a 25-mm lens in field and performance.

In conclusion, these cameras are not available to the general professional trade at the present time for obvious reasons. In the

interim, however, application of the lessons learned in field usage by the Armed Forces will result in refinement of design and mechanical improvement of eventual benefit to the industry's cameramen and technicians.

PROJECTION TELEVISION*

D. W. EPSTEIN** AND I. G. MALOFF†

Summary.—*Projection television, which is simply the projection onto a viewing screen of the picture originating on a cathode-ray tube seems, at present, to be the most practical means of producing large television pictures.*

The 2 basic problems of projection television are: (1) the problem of providing a cathode-ray tube capable of producing very bright pictures with the necessary resolution and (2) the problem of providing the most efficient optical system so as to utilize the largest possible percentage of the light generated. These problems were very vigorously attacked over a period of years and the progress made toward their solution has been very satisfactory.

Problem (1) has been solved largely by the development of cathode-ray tubes capable of operating at high voltages. Problem (2) has been solved by the development of a reflective optical system about 6 to 7 times more efficient than a good f/2 refractive lens. The reflective optical system consists of a spherical front face mirror and an aspherical correcting lens.

A handicap of this optical system, for use in a home projection receiver, was the high cost of the aspherical lens. This has been overcome by the development of machines for making aspherical molds and by the development of a process for molding aspherical lenses from plastics. RCA reflective optical systems are designed for projection at a fixed throw and require cathode-ray tubes with face curvatures fixed in relation to the curvature of the mirrors in the system. A number of such systems, suitable for projecting television pictures with diagonals ranging from 25 in. to 25 ft, have been developed.

People who have recently observed television programs are very pleasantly surprised to find that the brightness and resolution of the picture are quite satisfactory for entertainment purposes, but they express some dissatisfaction with the size of the picture—about 7 × 9½ in. This desire for larger pictures probably results from their experience with motion pictures. No amount of dissuasion or argument—such as, it is not the size of picture that matters but the angle subtended by the picture at the observer's eyes, or no one objects to the size of photographs in magazines, one simply observes them at close range—seems to decrease their desire for larger pictures.

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** RCA Laboratories, Radio Corporation of America, Princeton, N. J.

† RCA Victor Division, Radio Corporation of America, Camden, N. J.

Since the size of the picture obtainable on the face of a cathode-ray tube is definitely limited, means have to be found to enlarge the picture. An obvious means for obtaining larger pictures is to magnify the picture on the cathode-ray tube optically, by placing a lens in front of it. However, this means of enlarging the picture is of very little practical use since it limits the field of view very badly.

Another means for obtaining larger pictures is by the same means that is used in motion pictures, that is, by projection. Projection television is the projection onto a viewing screen of the television picture occurring on the luminescent screen of the cathode-ray tube. Projection television seems at present to be the most practical way of obtaining larger television pictures than are feasible with direct-viewing cathode-ray tubes.

Basic aims of RCA television research have been to develop both home and theater projection television. The 2 outstanding problems of projection television that had to be solved are:

- (1) The problem of developing a cathode-ray tube capable of producing very bright pictures with the required resolution; and
- (2) The problem of providing an optical system as efficient as possible so as to utilize the largest possible percentage of the light generated by the cathode-ray tube.

These problems were very vigorously attacked during the 5 years prior to our entry into the war and the progress made toward their solution was very satisfactory.

The progress made toward the solution of the cathode-ray tube problem resulted primarily from the development of cathode-ray tubes capable of operating at high voltages. This was the result of intensive work on electron guns, luminescent materials, glass envelopes, *etc.* Thus by the beginning of 1940 cathode-ray tubes had been developed which were capable of delivering more than 150 cp, whereas in 1935 the top was 10 cp—an improvement of over 15 to one.

In the beginning of the development, the problem of providing an efficient optical system appeared to be very formidable. In a television projection system the picture to be projected originates on the luminescent screen of a cathode-ray tube. For practical purposes, this screen radiates light as a perfectly diffusing surface. In projecting the light from a perfectly diffusing surface onto a viewing screen by means of a conventional lens by far the greatest part of the light does not reach the viewing screen. In fact, a lens with a relative aperture of $f/2$ can at most collect only 6.25 per cent of the light

emitted by the cathode-ray tube. Actually it collects appreciably less.

For a given power input to the cathode-ray tube the larger the tube face the greater the candlepower output. So it was necessary to provide an optical system capable of focusing large fields with high efficiency. A few per cent improvement of efficiency was of no interest. Manifold increase in the percentage of light delivered to the viewing screen was sought. In other words, an optical system was sought which should be able to cover up to 50-degree fields and should have an efficiency of 20 to 40 per cent instead of the 6 per cent of an

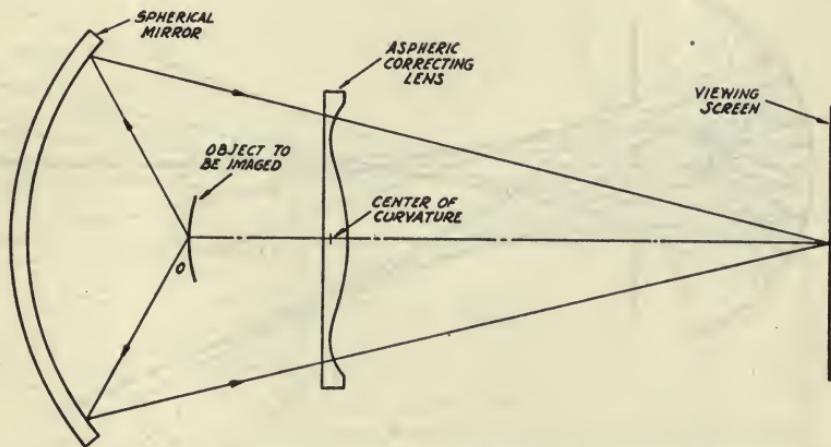


FIG. 1. Optical system consisting of a front surface spherical mirror and a weak nonspherical correcting lens located at the center of curvature of the mirror.

$f/2$ lens. The answer was found in a reflective optical system consisting of a front face spherical mirror and a weak aspherical correcting lens located at the center of curvature of the mirror. A schematic diagram of such an optical system is shown in Fig. 1.

The outstanding advantage of an optical system such as that shown in Fig. 1 over a more conventional optical system is its ability to focus a large field (large tube diameter) with a large relative aperture. This system possesses this property primarily because a spherical mirror with an aperture located at the center of curvature of the mirror suffers from only 2 aberrations, spherical aberration, which is uniform all over the field, and curvature of the field. This may be seen from Fig. 2; here C is the center of curvature of the mirror and O_1 and O_2 are object points located on the axis and off the axis, re-

spectively. Fig. 2 shows the ray paths for these 2 object points with the aperture located at the center of curvature. It is seen that the image or rather circle of least confusion, since spherical aberration is present, is practically of the same size and symmetry for both object points. As may be seen the reason for this is that the principal ray, *i. e.*, the ray passing through the object point and center of aperture, also passes through the center of curvature of the mirror and is therefore also an axis of symmetry for the sphere. The only difference is that the circular aperture mounted perpendicular to the principal

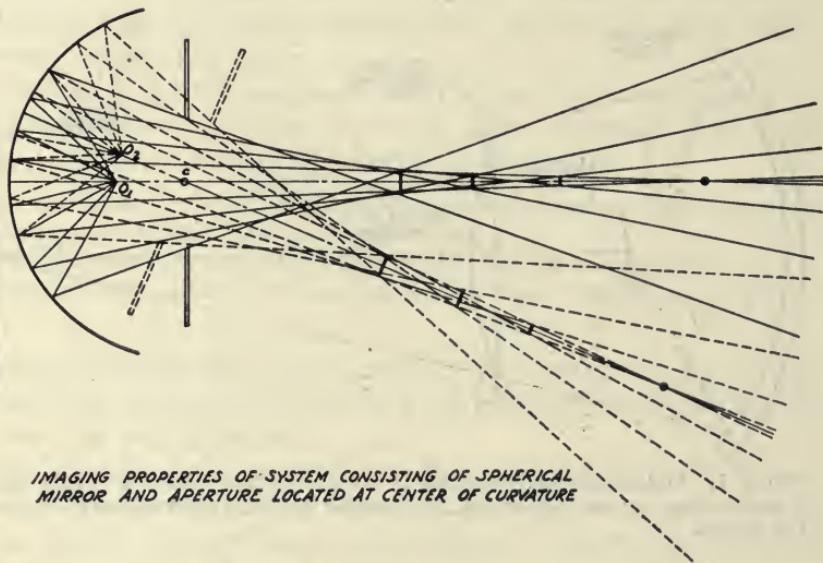


FIG. 2.

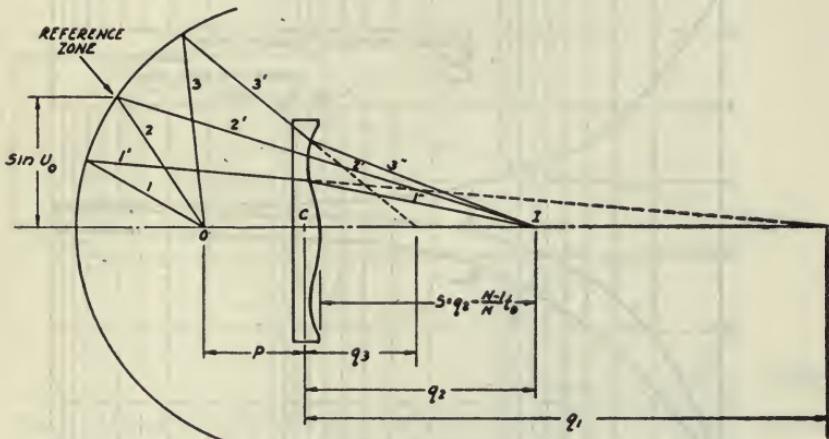
axis and therefore symmetrically located with respect to the principal axis is nonsymmetrically located with respect to the auxiliary axis. This causes some nonsymmetry in the light distribution of the circle of least confusion; however, this nonsymmetry becomes of importance only in the case of very large fields (large objects).

The object of the correcting lens is to correct for the spherical aberration of the mirror without introducing any serious aberrations in itself. This is accomplished by making the correcting lens as weak as possible and locating it in the plane of the aperture at the center of curvature. In this way, the symmetry property of the spherical mirror is least disturbed. The curvature of the field is not corrected

and is such that it is actually of advantage for cathode-ray tube projection.

The spherical aberration of the mirror may be looked upon as focusing by means of zones, each zone having a different focal length. The correcting lens has to be such that each zone of the correcting lens has a different focal length and such that it just compensates for the various focal lengths of the mirror and the resultant is a focusing system all zones of which have the same focal length.

The shape of the correcting plate must be such that all rays emanating from an object point O , and reflected by the mirror, shall meet at



CORRECTION OF SPHERICAL ABERRATION BY CORRECTING LENS

FIG. 3.

the image point I located at a distance S from the correcting plate. Fig. 3 shows 3 rays emanating from O and striking the mirror at different apertures. Without the presence of the correcting lens rays 1, 2, and 3 would intersect the axis at distances q_1 , q_2 , and q_3 from the center curvature. The slopes on the correcting lens have to be such (approximately as shown in this figure) that all 3 rays intersect at I , i. e., the correcting lens has a flat at the point where ray 2 passes, negative slope where ray 1 passes, and positive slope where ray 3 passes. Considered from the point of view of spherical aberration, if the zone where ray 2 strikes the mirror is taken as the reference, then the mirror has negative spherical aberration for smaller apertures and thus requires a positive lens for correction, and positive

spherical aberration for larger apertures and thus requires a negative lens.

Since the mirror with an aperture at center of curvature has no extra-axial or chromatic aberrations, these aberrations are caused by the correcting lens itself, *i. e.*, by the power or slopes on the correcting lens. From the standpoint of the aberrations, therefore, that shape should be chosen whose maximum slope is the least. Thus if the paraxial (central) focal length of the mirror is chosen as that of the system, then the central focal length of the correcting lens is infinite

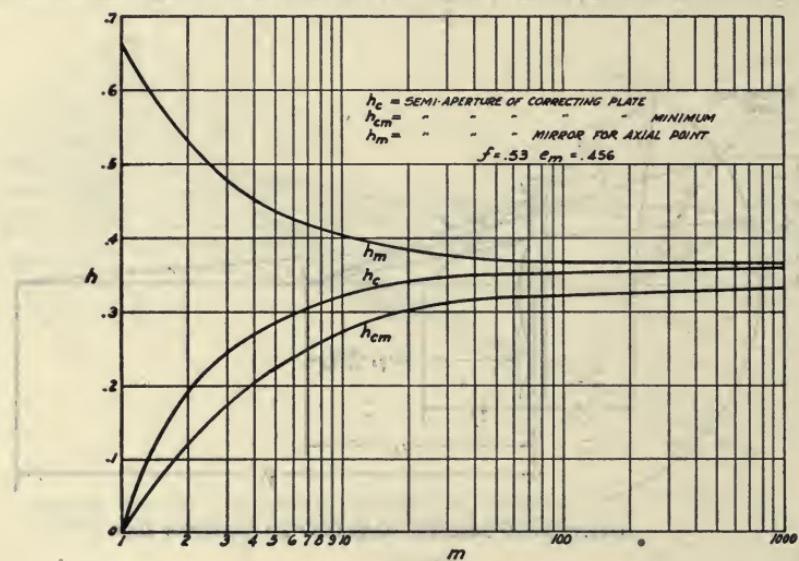


FIG. 4. Variation of semiapertures of correcting lens and mirror with magnification.

and the shape of the curve is concave. Alternatively, if a zonal focal length of the mirror is chosen as that of the system, there will be a zonal focal length of the correcting lens which is infinite and the shape of the curve is convex at the center and concave past this zone. If a peripheral focal length is chosen, the required correcting lens is convex. The maximum slope is least for a convex-flat-concave curve.

The shape and size of the correcting lens depend upon the throw or magnification for which the system is to be used. For a given focal length and relative aperture the correcting lens aperture decreases as the magnification decreases. That this must be so, may be sur-

mised from the fact that for unity magnification the lens aperture is zero, since object and image coincide at the center of curvature. Fig. 4 shows the variation of correcting lens semiaperature and mirror semiaperature with magnification. Thus a different correcting lens is required for each throw or magnification. The reason for this is that a high relative aperture optical system can be well corrected for only one position of object and image. The throw or magnification tolerance for a given correcting lens decreases with increased relative aperture for a given resolution.

In order to obtain a flat image field, *i. e.*, focus on a flat-viewing screen, it is necessary that the object field or tube face be curved.

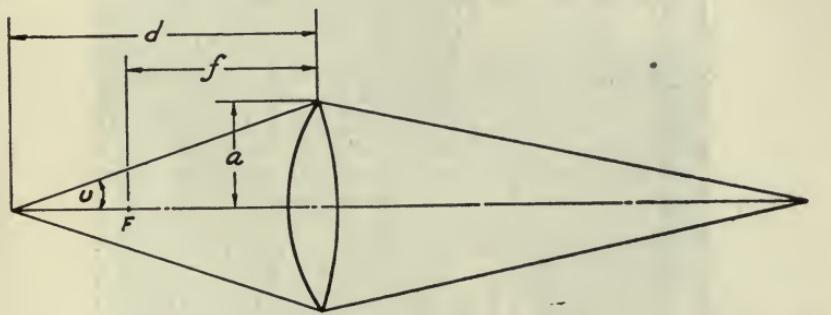


FIG. 5. Illustration by means of a simple lens that efficiency decreases with magnification.

Calculations show that in general the shape of tube face depends on the throw—a sphere for infinite throw and an ellipsoid for finite throw. The eccentricity of the ellipsoid is sufficiently small, however, so that even for finite throw the tube face may be made spherical with a radius of curvature equal to that of the focal length of the system.

The projection efficiency of any optical system will be defined as the fraction of the total light flux (say, in lumens) emitted in a forward direction by an axial element of a nondirectional source, such as the luminescent screen of a cathode-ray tube, that the optical system accepts and focuses on the corresponding image element, assuming that the mirror reflects 100 per cent and the lenses transmit 100 per cent.

The efficiency, e , as defined above is given by

$$e = \sin^2 U$$

where U is the semiapex angle shown in Fig. 5. Hence to determine the efficiency of a lens, for a perfectly diffusing source, it is merely necessary to know the angle that the lens (or entrance pupil) sub-

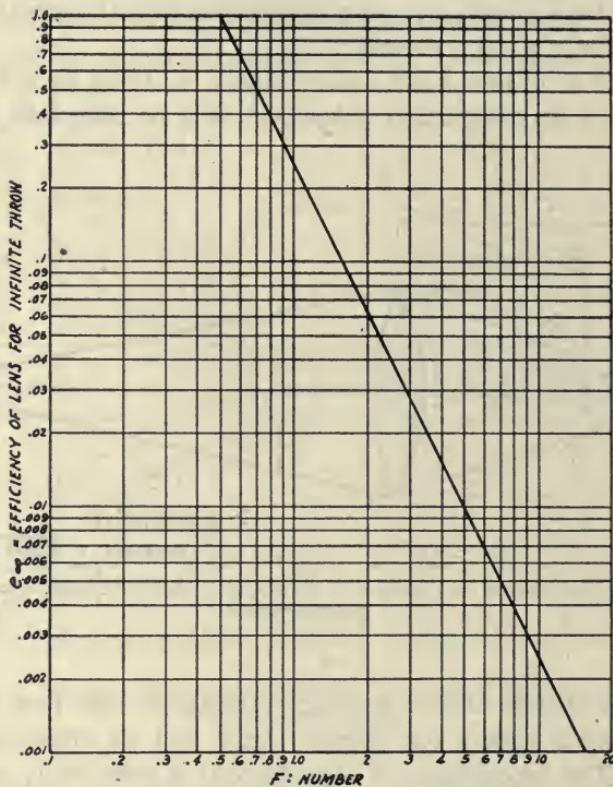


FIG. 6. Variation of lens efficiency with its f /number.

tends at the source. As may be seen from Fig. 5, the farther a given lens is from a source, *i. e.*, the less the magnification, the lower the efficiency of the lens.

It has become customary to rate a lens by its f /number for infinite magnification, *i. e.*, object located at the focal point of the lens. The f /number is defined as

$$f/\text{number} = \frac{1}{2 \sin U} = \frac{1}{2 \sqrt{e_\infty}}$$

where e_∞ is the efficiency for infinite magnification. The smallest f/number possible is 0.5, since at 0.5 the efficiency is unity and all the light emitted by the object element in a forward direction is concentrated at the image element. Fig. 6 shows the efficiency e_∞ of a lens as a function of f/number . It is seen that the efficiency of most lenses is very low.

As already mentioned the efficiency of a given lens decreases when the magnification or throw decreases. This factor becomes of im-



FIG. 7. RCA theater television projector, with control console in background.

portance in the case of home projection where magnifications as low as 5 may be used. Thus an ordinary $f/2$ lens having an e_∞ of 6.25 per cent will have an efficiency of 4.6 per cent when used for a magnification of 6.

Since the reflective optical systems under consideration are designed for a specific magnification and since the central part of the system is masked to maintain contrast, this part being blocked by the cathode-ray tube, it seems preferable to rate such systems by their efficiencies rather than f/number .

In the RCA systems the efficiency with no masking is about 40 per cent and the efficiency of the central part of the system that is masked

is approximately 10 per cent so the efficiency of the system with blocking will be about 30 per cent, and hence neglecting losses in the system, about 30 per cent of the light emitted by an axial point will be focused into an image point. This corresponds to the efficiency of an $f/0.8$ lens used at a magnification of 6.

There are 2 distinct applications for projection television, namely, theater television and television receivers for home use. A description of the RCA theater television system has been published in the July, 1941, issue of the *RCA Review*. The optical system consists of a 30-in. diameter mirror and 22.5-in. diameter correcting lens. Fig. 7 shows the optical system with the cathode-ray tube in place. The control console may be seen in the background. Fig. 8 shows an arrangement of parts in a self-contained projection television receiver. Here the optical system is mounted near the floor with its axis vertical, projecting the image straight up and onto a flat mirror inclined at 45 degrees to the incoming beam of light, and throwing the image on a translucent screen. Such an arrangement presents the advantages of compactness, relatively small depth of the cabinet,

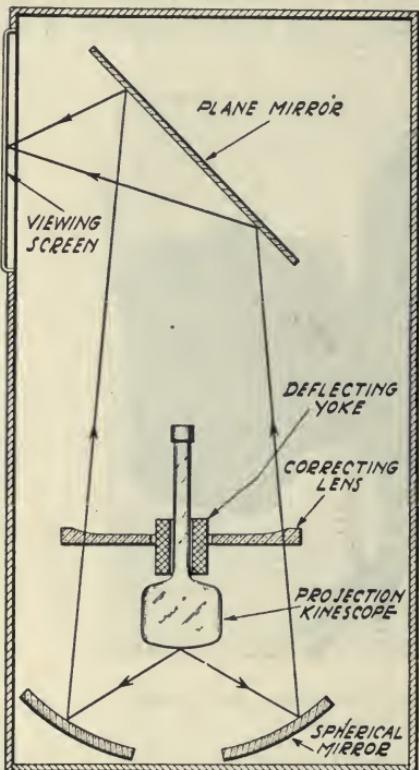


FIG. 8. Optical system of television projection receiver.

and can be styled along the familiar lines of a radio console. A number of such reflective projection systems suitable for home receivers of the type described have been designed, built, and operated in actual receivers. The smallest of these was built for use with a cathode-ray tube having a face diameter of 3 in. and consists of a spherical mirror 9 in. in diameter and a correcting lens 6 in. in diameter. The largest has tube, mirror, and lens diameters of 5, 14, and 9.5 in., respectively. A number of systems in sizes intermediate between the

two just described have been built. The throw or distance between the correcting lens and the viewing screen varied between 36 and 54 in. and the optical efficiencies were between 18 and 35 per cent. In resolution and contrast these systems compare favorably with well-corrected conventional projection lenses.

The major objection to the use of reflective optics in home projection receivers was the high cost of the aspheric correcting lens. The spherical mirror, while quite large, is an old and familiar item to the well-established optical industry, as most of the conventional optical



FIG. 9. Machine used in making the metal mold.

surfaces are spherical and are easily made. The aspherical correcting lens similar to a figure of revolution developed by rotating a shallow letter *S* around one of its ends, presented an altogether different problem. Unlike the spherical mirror such a figure is not a naturally generated surface and there are no machines on the market for straightforward production of such surfaces. True enough, astronomers, with their traditional patience and lack of hurry, produced excellent aspherical lenses on machines used for making astronomical instruments, but only by tedious step-by-step methods.

In the early stages of the development RCA used methods and machines copied from astronomical techniques. Exceedingly high

cost of experimental reflective optics resulted. The gain in light over the conventional projection lens was very attractive, but the cost of such individually produced lenses was prohibitive. The apparent solution to the cost problem was that of molding the aspherical lenses from some transparent material. A development project was undertaken and soon was concentrated on the investigation of a clear thermoplastic material known under the name of methyl methacrylate, and sold under the registered trade names of Lucite and Plexiglas.



FIG. 10. Open molding press showing the lens attached to the upper molding surface by its flash.

A new set of difficult problems came to the foreground. The most formidable of these was that of making molding surfaces of metal in shapes of the negative replicas of aspherical lenses. About as serious was the problem of obtaining optical finishes on metals. Both of these problems have been successfully solved.

Fig. 9 shows a machine used in making the metal mold. The molding process is essentially that of applying very high pressure to heated plastic material confined in a heated mold and cooling it under pressure until it reaches room temperature. The mold is then opened and the lens extracted. A view of an open molding press with the

lens attached to the upper molding surface by its flash is shown in Fig. 10. The only operation which remains is that of boring a hole in the center of the lens for accommodating the protruding neck of the cathode-ray tube. The lens is then ready for use with no polishing or finishing of any sort required.

Molded correcting lenses for reflective optical systems suitable for home projection receivers possess very good optical properties, including slightly better transmission and slightly less scattering of light than glass. They do not possess the surface hardness and scratch resistance of glass, but even without any special care or protection they have stood up under laboratory operation for more than 3 years. The cold flow under operating conditions of 3 years was found negligible. The cold flow depends on the operating temperature which for the plastic lens of a television receiver is not far from the room temperature.

So far only the smaller correcting lenses suitable for home projection receivers have been molded. The larger correcting lenses necessary for theater projection were produced from glass.

The RCA reflective optical systems are designed for projection at a fixed throw and require cathode-ray tubes with face curvatures fixed in relation to the curvature of the spherical mirror. A number of these systems have been developed, suitable for projecting television images with diagonals ranging from 25 in. to 25 ft.

A DISPLACEMENT METER FOR TESTING UNSTEADINESS IN MOTION PICTURE PROJECTORS

RON W. JONES*

Summary.—*There has been need for a simple device to measure with reasonable accuracy the degree of unsteadiness in 35-mm projector mechanisms, particularly where such mechanisms are overhauled and must be tested in a workshop. The following paper describes a simple technique which provides for an actual metering of the unsteadiness factor in terms of maximum displacement between any 2 frames during the running of a test film bearing on a suitable target.*

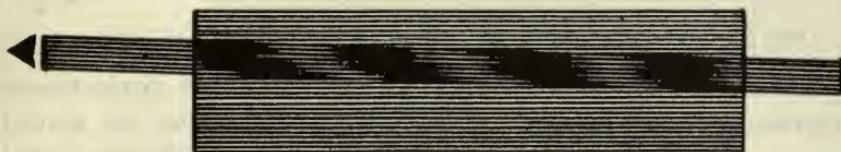
For some time past the need has been felt for a satisfactory method of measuring, with a reasonable assurance of accuracy, the degree of unsteadiness in projector mechanisms. This applies particularly in cases in which mechanisms are overhauled and must be tested in the workshop before delivery back into the field. In the theater one may judge fairly well whether or not a projected picture is within reasonable limits of vertical jump and lateral weave. In workshop testing, however, the main difficulty arises out of the impracticability of simulating actual theater conditions in respect of picture size, length of throw, etc., and although picture movement is directly proportional, entirely misleading impressions result from the use of miniature screens. Moreover, measurement of movement at the screen by means of direct scaling is, to say the least, difficult and invariably leaves the engineer with a feeling of uncertainty.

Experimental work in this direction has led to the evolution of a simple technique based on similar principles to that described in the July, 1944, issue of the JOURNAL for the testing of motion picture cameras.¹ The system herein described provides for what may be termed the actual metering of the unsteadiness factor in terms of maximum displacement between any 2 frames during the running of a test film bearing a suitable target.

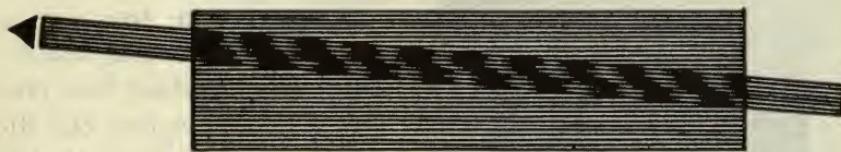
The film target pattern for vertical jump consists simply of a grating

* Western Electric Company (Aust.) Pty., Ltd., Brisbane, Australia; received Jan. 24, 1945.

or series of horizontal black lines of even thickness extending over the entire frame area and separated by clear spaces of equivalent thickness. This is projected onto the face of the meter which carries a flat beam 2 in. wide and 13 in. long, ruled along its length with black lines of equal thickness and spacing to those of the film pattern at a pre-determined throw. The beam is capable of being moved about its center through 360 degrees in a plane at right angles to the optical axis of the projector.



Beam angle = 2°



Beam angle = 5°

FIG. 1. Effects of intersection of the projected and ruled gratings at various beam angles.

Any angle between the projected and ruled gratings produces dark patches, occurring at intervals along the beam, as shown in Fig. 1, owing to the intersection of lines and spaces.

Vertical jump in the projected image results in a horizontal shifting of these patches which is not only extremely obvious but is also readily measured.

The explanation of this is simplified by reference to Fig. 2 in which the action is represented by taking only one line *AB* of the projected

grating and one line CD of the ruled grating. Let us assume the maximum displacement between 2 frames to bring about a shift of

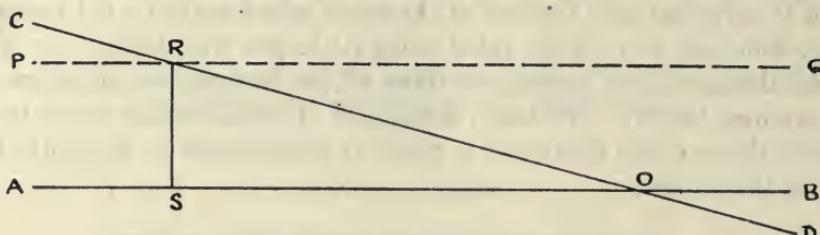


FIG. 2. Action represented by taking one line only of each grating.

the line AB to a position indicated by PQ . Then the displacement is represented directly by RS and the intersection point has moved

from O to R , a distance equal to OS on the line AB .

Taking X as vertical displacement, Y as lateral movement of the intersection point, and ϕ as the angle between the 2 gratings, then:

$$X = Y \tan \phi$$

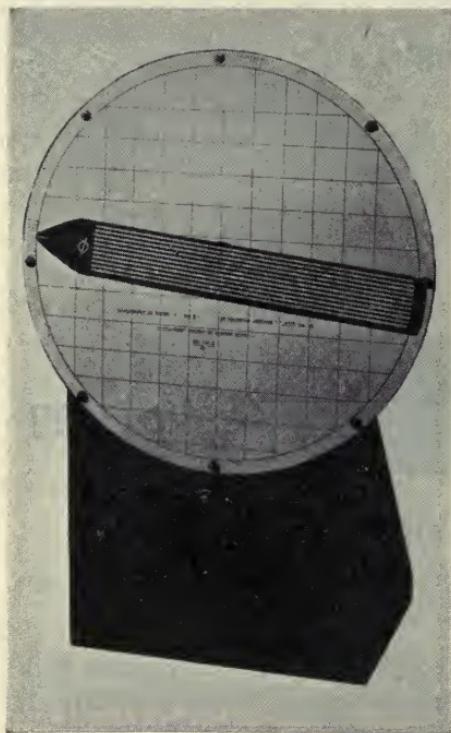


FIG. 3. Face of meter showing arrangement of dial and beam.

A knob, friction driving the edge of the dial, provides for quick adjustment about its axis for the purpose of aligning it with the film

The ruled beam is mounted immediately in front of a 14-in. diameter white dial divided by thin black lines into one-inch squares (see Fig. 3). A scale is provided at the outer edge of this dial, calibrated from zero at a point horizontally opposite center, to 10 degrees in a clockwise direction. An index point on one end of the beam permits of the beam angle being read off along this scale. Ten degrees has been found to be an ample range for all practical purposes.

pattern. The beam angle is also controlled by means of a knob belt driving the beam shaft. The mechanical arrangement is illustrated in Fig. 4. The operation of the device is as follows:

The test film is run at normal speed and projected onto the dial which is then adjusted to bring the horizontal division lines parallel with the film pattern.

The beam is then rotated from zero to a position at which the dark

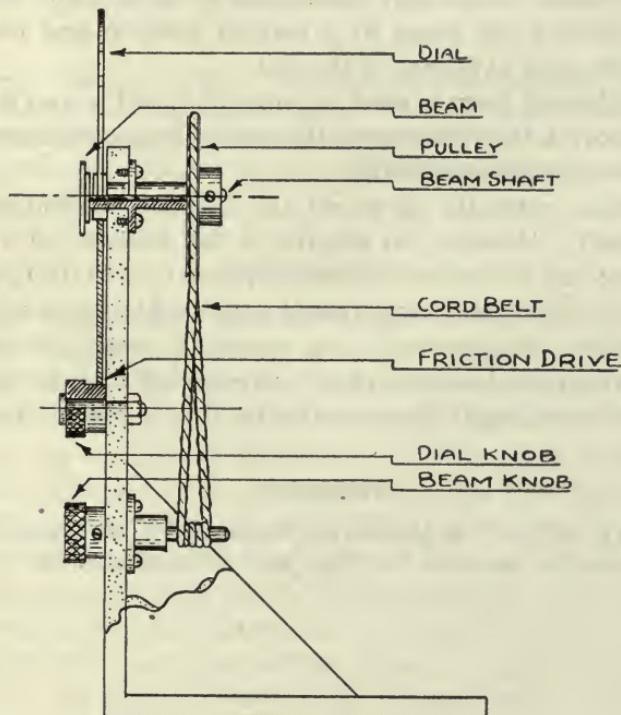


FIG. 4. Mechanical arrangement of the meter.

patches appearing on it, shift back and forth along it a distance equal to one of the squares on the dial. This represents a back and forth travel of the intersection points of one inch and enables us to read the direct displacement between frames as a decimal of one inch. In other words:

$$\text{Frame displacement} = \tan \phi \text{ inches}$$

In our own particular case the selected throw for matching of the gratings gives a projected mask image 22 in. wide at the face of the

meter, so that we may read displacement as a percentage of picture width thus:

$$X \text{ as per cent picture width} = \frac{100 \tan \phi}{22}$$

The angle is read off along the scale and its tangent obtained from a set of 4 figure tables.

Similarly lateral weave may be checked by using a film with vertical lines, rotating the beam to a vertical position and reading off along another scale at the top of the dial.

An incandescent lamp is used for projection and a stop is inserted in the lens barrel, thus sharpening the grating image considerably and making for more accurate result.

This system naturally shows up any inherent inaccuracy in the test film itself. However, in practice it has worked out very well, enabling us to set a standard tolerance of from 0.25 to 0.30 per cent of picture width, each case being treated according to its own particular characteristics. Requirements are naturally much stricter for a projector which has been completely overhauled than for one which has, for instance, simply been readjusted after a period of operation in the field.

REFERENCE

¹ TOWNSLEY, M. G.: "A Method for Measuring the Steadiness of Motion Picture Cameras," *J. Soc. Mot. Pict. Eng.*, 43, 1 (July, 1944), p. 45.

EXPERIENCE WITH AN FM CALIBRATOR FOR DISK RECORDING HEADS*

H. E. ROYS **

Summary.—Previous methods of calibrating disk recording heads are reviewed and a new method which utilizes a push-pull FM system is considered. The new method permits calibration during actual cutting of the disk and so has a distinct advantage over the older methods. Results obtained with a recording head and lacquer disks are discussed.

INTRODUCTION

Since the beginning of disk recording, a device has been needed which would permit the calibration of a recording head under actual cutting conditions. For years the head has been calibrated by mounting it under a microscope and measuring the amplitude of the stylus vibration in air at different frequencies. The correctness of this procedure was based upon the assumption that the load imposed upon the stylus by the recording material during cutting was small in comparison with the mechanical impedance of the recorder and therefore introduced no appreciable error. This assumption was justified by showing that the width of the reflected sunlight pattern of a frequency record, recorded at constant stylus velocity, appeared constant in width across the disk, as theoretically it should when viewed under suitable light conditions.

SUNLIGHT PATTERN METHOD

The sunlight or "Christmas tree" pattern as it is sometimes called is a satisfactory means of making an over-all calibration and is in common use. It is accurate providing certain precautions are taken such as having a small source of light located some distance away so that the light rays are parallel (if the sun is not used), having the rays strike the disk nearly parallel to its surface, and observing the re-

* Presented Oct. 16, 1944, at the Technical Conference in New York.

** RCA Victor Division of Radio Corporation of America, Indianapolis, Ind.

flected pattern at right angles to the plane of the disk, some 3 or 4 ft away, while viewing with only one eye.

At the center of the pattern an unmodulated groove makes an angle of 90 degrees with the incident ray, and reflects a beam of light to the eye. Elsewhere the unmodulated groove appears dark. With modulation present, visible reflections occur, because despite the departure of the groove axis from the 90-degree direction, some point exists on each wave where the angle, owing to modulation, cancels the angle owing to the change in mean direction, and hence for a very short distance within each wave the groove is again at the 90-degree position (or parallel to the tangent at the center of the pattern). Beyond a certain distance from the center, the groove axis angle has become so large that this cancellation of angles can no longer occur, and this condition marks the edge of the pattern. As the groove diameter decreases, its mean curvature increases, but at the same time the waves get shorter and the modulation slopes (for a given amplitude and frequency) increase in the same proportion. Whence the width of the pattern is not altered by a change in groove diameter.

The method is mainly one of comparison, the width of one frequency band being compared with that of another and it does not lend itself readily to quick accurate checks needed during initial calibration. It is valuable, however, in making a final test on the recording head and in checking the flatness of the constant velocity portion of a frequency recording.

MICROSCOPE METHOD

The microscope method is suitable for initial calibration especially if adjustments can be made without removing the head. But the method is slow and tedious, and is inaccurate at the higher frequencies where, owing to constant stylus velocity, the amplitude of motion is small and the spot of light is no longer small in comparison with the amplitude of movement. Most recorders maintain constant amplitude stylus motion below a frequency, known as the cross-over frequency, and constant velocity above, so that at the higher frequencies the amplitude decreases since the product of frequency and amplitude must remain constant for constant velocity motion. Constant amplitude at the lower frequencies is, of course, necessary to prevent over-cutting, unless excessive spacing of grooves is resorted to with the accompanying loss of playing time.

PHOTOELECTRIC CELL METHOD

The microscope method was improved upon by substituting a photoelectric cell for the eye and having the stylus modulate a light beam being transmitted to the cell. Calibrators of this type have been in use for some years and in general have proved to be accurate and reliable. They do not, however, permit calibration while cutting a disk.

FM METHOD

The problem of being able to calibrate the recorder under actual cutting conditions was finally solved by the FM system developed by

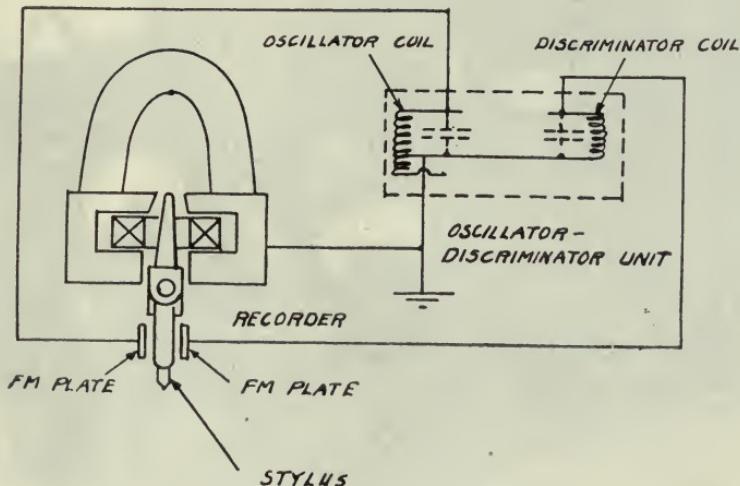


FIG. 1. Arrangement of FM plates.

my colleague, Alexis Badmaieff. Here was a device which could be attached to the recorder without requiring much space, or adding mass to the moving system, one which would not couple electrically to the driving coils of the recording head and which could be so arranged as not to interfere with the cutting action of the stylus.

Fig. 1 shows the arrangement. Two tiny plates, one on each side of the stylus shank or stylus bar, insulated from each other and from the recorder, are spaced a few thousandths of an inch from the stylus. Neither mass nor stiffness is added to the moving system so there can be no change in its mechanical action. Flexible leads from these plates are connected to the oscillator-discriminator unit mounted on the carriage located close to the recorder. Variation of capacitance between the plates and the stylus owing to its motion changes the

oscillator frequency and tuning of the discriminator. The audio output from the rectifier of the oscillator-discriminator unit is transferred to a stationary unit, Fig. 2, containing an amplifier and a power supply. The output from this amplifier is then either measured by means of a tube voltmeter or further amplified for listening or other purposes.

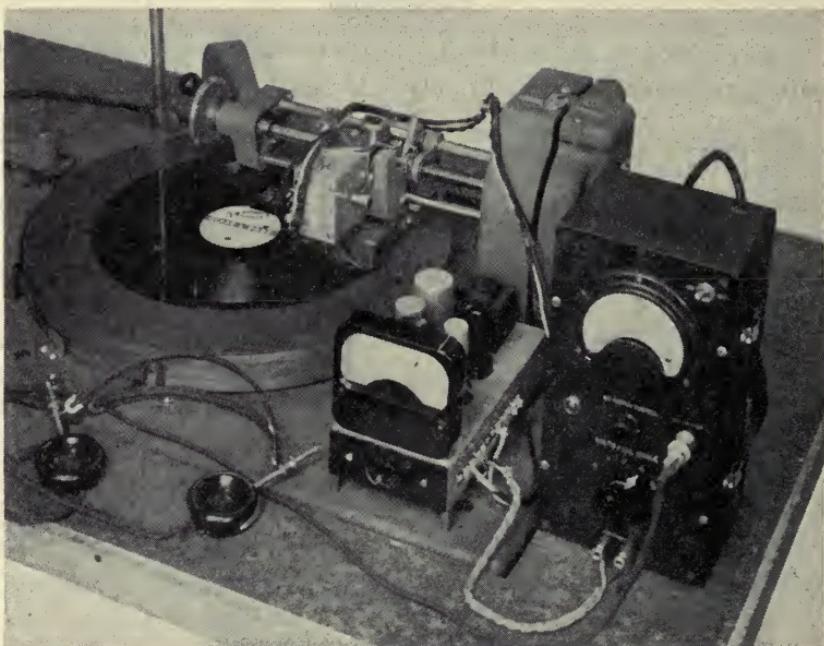


FIG. 2. Equipment in operation.

COMPARISON OF FM AND OPTICAL CALIBRATORS

One of the first tests was a comparison of results obtained with the FM and optical calibrators using the RCA *MI-11850* recorder which has the same performance as the *MI-4887* recording head. Owing to the small size of the FM plates it was possible to have them in place while the recorder was mounted in the optical calibrator so that a direct comparison was easily made. The results of frequency response measurements made in this manner are shown in Fig. 3 and a very close agreement is noted between the 2 methods except at the low frequency end, where the characteristics of the amplifier used in the optical calibrator caused some increase in the response.

CHANGE IN FREQUENCY RESPONSE FROM CUTTING LOAD

The most important advantage of the FM calibrator is realized when investigating the change in frequency response owing to cutting load, for with it measurements can be made under actual cutting conditions. Several factors must be considered when making these measurements such as the record material, the stylus with its burnishing edge, the turntable speed and recording diameter, and the test frequency. Early tests showed what had been predicted, that the greatest effect of the cutting load would be at the resonant fre-

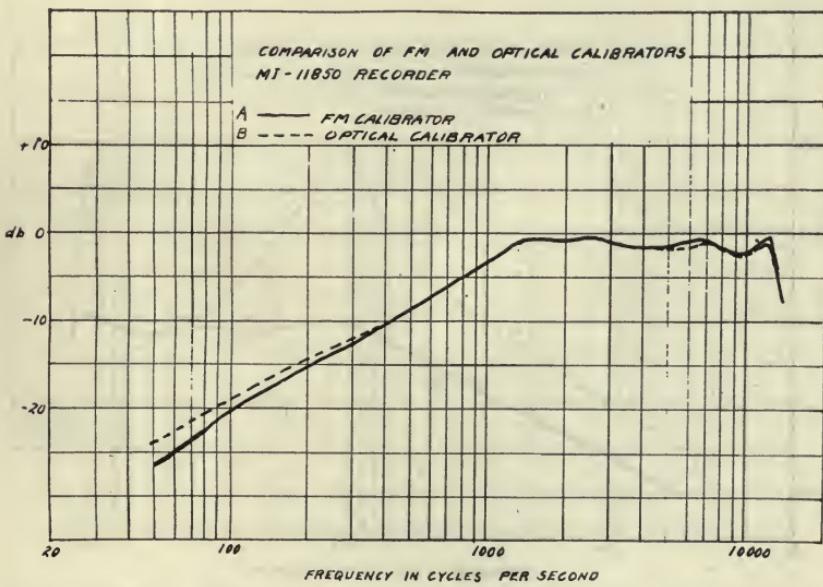


FIG. 3.

quencies of the mechanical system. Fig. 4 shows the response characteristic, in air, of an undamped recording head and also the response after the viscoloid damper block has been added. It will be noted that there are 2 resonant frequencies, one about 1000 cycles and the other about 10,000 cycles, and that the damper block has little effect on the frequency response between 5000 and 8000 cycles.

Fig. 5 shows the cutting load loss as a function of groove velocity, at several different frequencies, the groove being cut in lacquer with a sapphire stylus having a tip radius of approximately 2 mils, a 90-degree included angle, and the usual burnishing edge. For this particular recorder which had the high-frequency peak at 12,000

cycles instead of 10,000, the greatest loss owing to the cutting load occurred at 1000 cycles, the fundamental resonant frequency of the mechanical system. The least loss occurred at the lower frequencies and in the region from 5000 to 8000 cycles, which was predicted from the damped and undamped curves. The curves of Fig. 5 show that over the diameters and turntable speeds normally covered in $33\frac{1}{3}$ and 78 rpm recordings, the loss is small. For a $33\frac{1}{3}$ -rpm recording at the innermost diameter, the 1000 cycle loss, when compared to that of the maximum diameter, is approximately 1.2 db which is not very

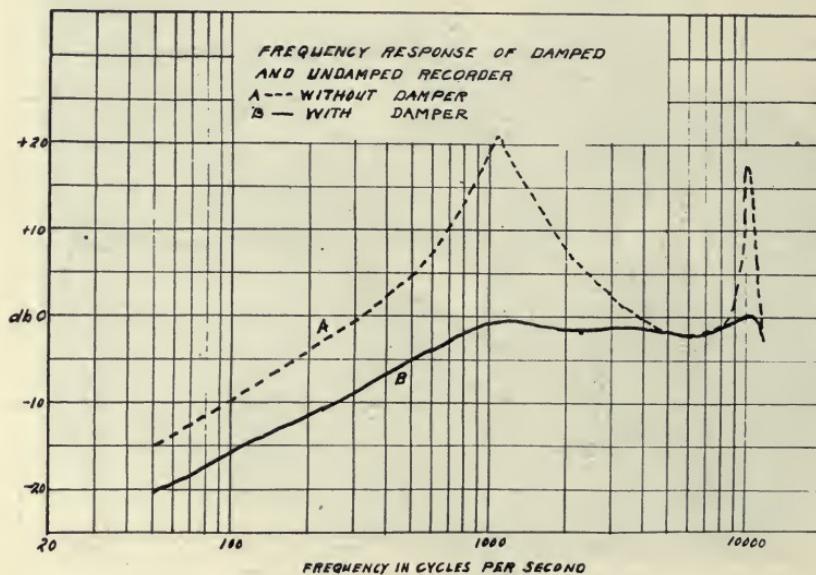


FIG. 4.

great. Styli with larger burnishing surfaces may increase this loss and tests with 10 new stylus showed an average loss of about 1.7 db, or one-half a db more than the previous test. At 78 rpm the loss at 1000 cycles between the inside and the outside of the disk is approximately 1 db.

The effect of loading is also shown in Fig. 6 in which the results are plotted in the usual frequency response manner. Curve *B* shows the response that can be expected near the outside of a 12-in. disk at 78 rpm. The lower curve *C* shows the response near the inside of a $33\frac{1}{3}$ -rpm disk. At 1000 cycles a difference of 2 db was measured and at the upper resonance a greater loss, 3 db in this case, was observed.

Elsewhere the loss was less, and between 4000 and 6000 cycles no loss was experienced, likewise no loss was observed at 50 and 100 cycles. The upper curve *A* is an air calibration, that is, with the stylus vibrating in air and not cutting the lacquer. The 2 lower curves *B* and *C* show the extreme losses to be expected between the inside of a $33\frac{1}{3}$ -rpm disk and the outside of a 12-in. diameter 78-rpm disk.

CHANGE IN RECORDING LEVEL WITH GROOVE WIDTH

Previous tests have shown that the greatest loss from loading occurs at the resonant frequencies of the mechanical system. Since the peak

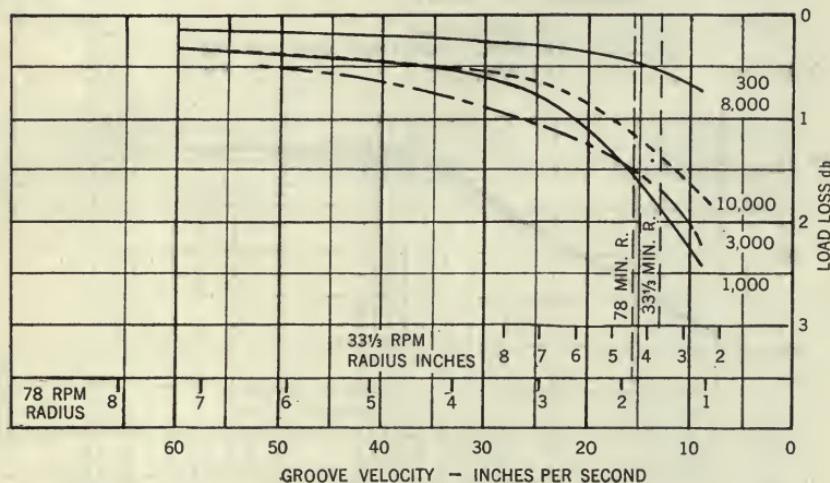


FIG. 5. Cutting load loss—MI-11850 Recorder and lacquer disk.

is broader at the 1000-cycle resonance, there is less likelihood of errors from frequency shift of either the applied signal or the mechanical system. Therefore, the change in recording level with depth of cut was investigated at 1000 cycles. Ten styli were measured for level loss at 1000 cycles and an average one chosen. Of these ten the average load loss for a groove 5 mils in width was 2.9 db, the maximum loss was 3.2 db and the minimum 2.7 db. The sapphire had a tip radius of approximately 2 mils and an included angle of 90 degrees. Fig. 7 shows the results of changing the depth of cut which is expressed in groove width since this is easy to measure with a microscope. Curve *A* shows the loss obtained at the inside of a $33\frac{1}{3}$ -rpm recording. Curve *B* shows the loss obtained at the outside of a 12-in. disk at 78 rpm. Curves *C* and *D* are the results of similar tests

with a steel stylus instead of a sapphire. The steel stylus had no burnishing edge or tip radius and had an included angle of 90 degrees. The change in level is not very great except at the lower groove velocities such as occur at the inside diameter ($7\frac{1}{2}$ in.) of a $33\frac{1}{3}$ -rpm recording. At this diameter a groove variation from 4 to 5 mils resulted in an amplitude reduction of approximately 0.6 db. The variation in groove depth could occur owing to cutter bounce or flutter

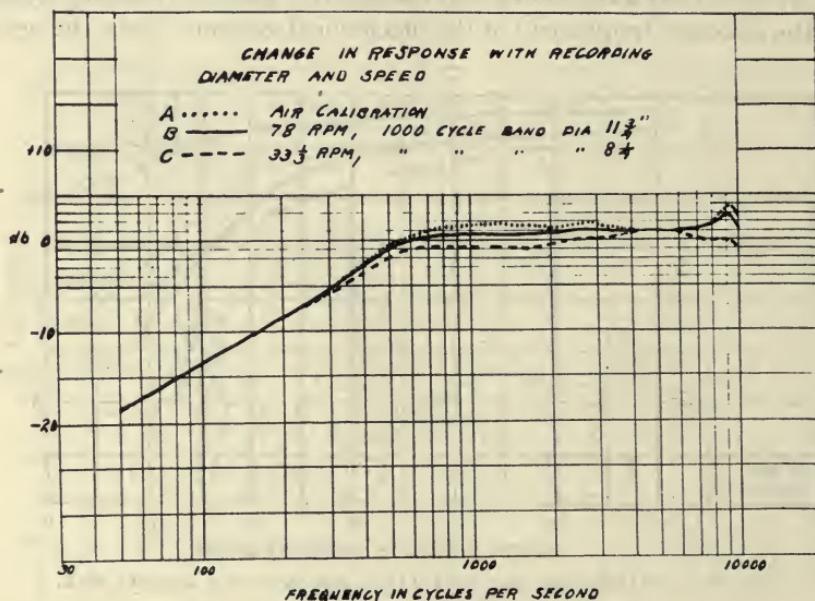


FIG. 6.

which fortunately is usually less at $33\frac{1}{3}$ than at 78 rpm, or to irregular surface of the blank.

DISTORTION

Another requirement of a good calibrator is that it be free from distortion so that accurate measurements of the recording head distortion may be made. An over-all distortion measurement which includes the disk and pickup is not satisfactory since it does not permit segregation of the amounts introduced by the recording and reproducing heads. Since the FM calibrator is an amplitude device, it is only necessary to limit the range over which the FM system operates

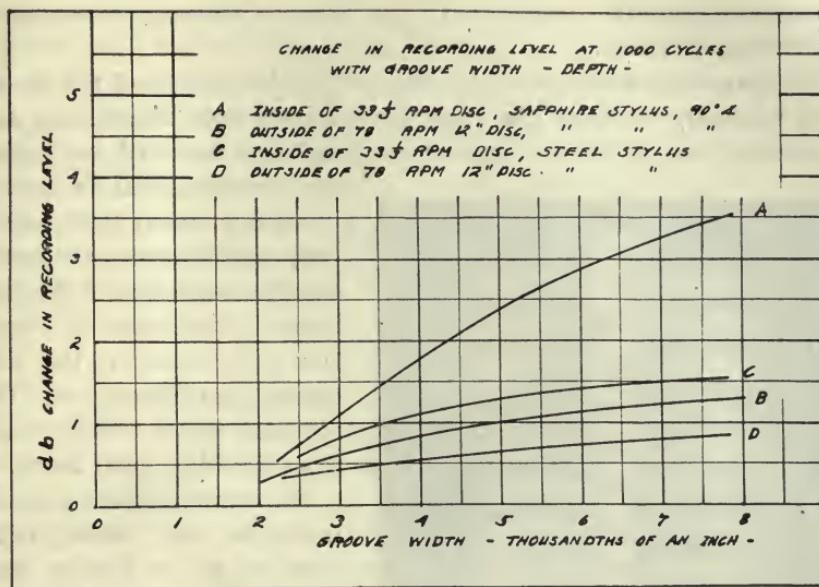


FIG. 7.

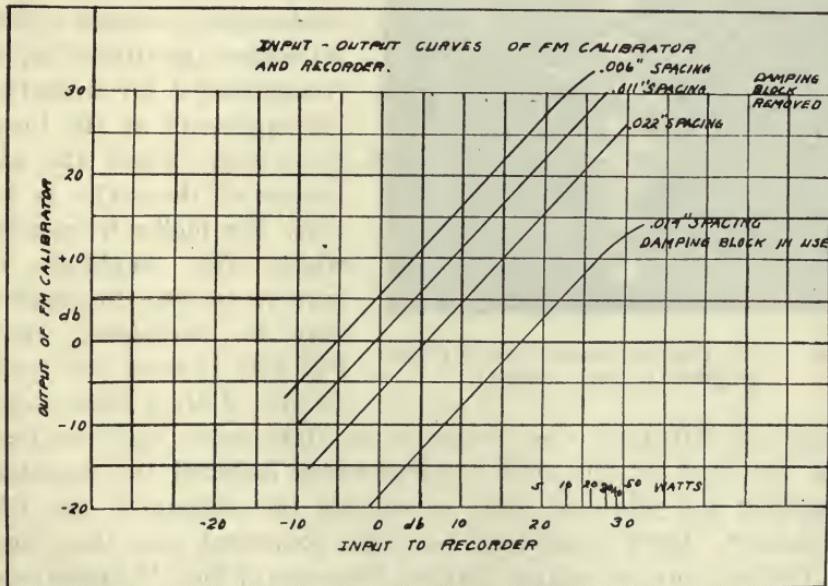


FIG. 8.

in order to keep the distortion at a low value so that accurate measurements may be made.

To determine what spacing between the FM plates and the stylus was necessary to fulfill this requirement, tests were made using the recording head with the viscoloid damping block removed, so that at

the fundamental resonant frequency, about 1000 cycles, very little electro-magnetic energy was required to give normal amplitudes of vibration and therefore the distortion introduced by the recorder under these conditions would be quite low.

Numerous distortion measurements at 1000 cycles were made at various amplitudes of vibration and plate separation. In addition, input-output or linearity measurements were made and as a result a plate separation of 0.015 in. is recommended for distortion measurements at the lower frequencies, where the amplitude of the stylus is ± 3 mils. For higher frequencies where the amplitude of motion is less the spacing may be decreased, which will also increase the sensitivity. With a plate sepa-

FIG. 9. A test frequency record photographed in the sunlight.

ration of 0.015 in. the distortion at 1000 cycles was less than one per cent for the entire system which included the recording amplifier and the one used to amplify the output of the FM calibrator. These amplifiers measured somewhat less than one-half of one per cent each, so that the distortion of the FM system was of the same order for the highest amplitudes of vibration likely to be encountered. The results of the input-output curves are shown in

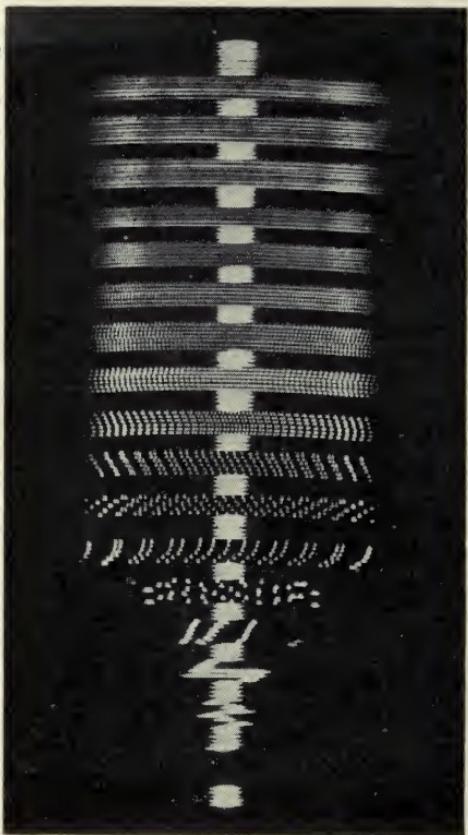


Fig. 8. Some curvature will be noted with the 0.006-in. spacing and likewise with the 0.014-in. spacing when the damping block was in place, the nonlinearity being chargeable to the recording head in this case. With the damper block in place the over-all measured distortion at 1000 cycles was about 1.5 per cent at normal recording level. The distortion measurements were made using the RCA distortion meter in which a signal is used directly from the oscillator to balance out the fundamental of the signal being measured, the residue being the total harmonic distortion.

MONITORING

The FM calibrator was designed primarily for calibrating purposes, but may also be used for monitoring, as such it is ideal when cutting frequency recorders for reproducer tests. The recorder can be carefully calibrated beforehand and the correct input level for each band determined. Then when cutting the final disk the calibrator may be used as a check on the recording level, making slight corrections if necessary, or if it is undesirable to change the level during recording, the correction can be noted and applied afterward when using the disk. A test frequency record was made using the latter procedure and a photograph of it taken in the sunlight is shown in Fig. 9. The variation of the constant velocity section from true flatness is only a few tenths of a db.

THE POTENTIOMETRIC DETERMINATION OF BROMIDE IN THE PRESENCE OF CHLORIDE IN PHOTO- GRAPHIC DEVELOPER SOLUTIONS

WILLIAM R. CROWELL,* WAYNE W. LUKE,* AND
HARLAN L. BAUMBACH**

Summary.—In the present work a potentiometric method of determining bromide in the presence of chloride in developer solutions has been studied. For a given concentration of bromide the error in titration depends upon the ratio of the concentration of the chloride to that of the bromide and is materially affected by the presence of developer solution constituents. Percentage correction curves are shown which can be applied to bromide titrations in the various solutions at different concentration ratios of chloride to bromide including those bromide concentrations common in developer solution analysis. A method of analysis more rapid than any mentioned in the literature and which is now used in a leading West Coast motion picture laboratory is described.

The main objective of the present investigation was to develop a method of determining bromide in photographic developer solutions with a view of applying this method to routine analyses in motion picture laboratories. The chief characteristics of such a method should be that it be rapid and at the same time possess adequate accuracy and precision for the work in hand. A potentiometric titration of the bromide with silver nitrate seemed to offer the greatest promise of success. Chloride, while not having any appreciable photographic influence on the film, does offer interference in the bromide titration. While iodide has a definite effect on the character of the developed film, it is seldom present in quantities great enough to interfere with the potentiometric determination of bromide and, therefore, is not considered in this study.

Considerable material is in the literature on the potentiometric determination of the individual halides and of halide mixtures. In the case of the individual halides accurate results in neutral or acid

* Chemistry Department, University of California at Los Angeles; received March 26, 1945.

** Paramount Pictures, Inc., Hollywood.

solutions have been obtained.^{1,2,3} In the case of mixed halides, however, the points of inflection in the titration curves obtained by plotting volumes of silver nitrate against emf did not coincide with the equivalence points.^{1,4,5,6} Liebich⁶ found that by the addition of barium nitrate or alum to the halide mixture solutions the inflections in the titration curves were sharpened and the inflection points brought nearer to the equivalence points. Clark¹ and Flood and Sletten⁴ have also found that salts have a favorable influence on the end points. Tomiček and Jansky⁷ found that in sodium sulfite solutions halide mixtures could be titrated with accuracy only when the solutions were definitely acid. No data are reported on the effects of hydroquinone, metol, or gelatin, or of all of the typical developer solution constituents when present together on the bromide-chloride end point.

Recently a potentiometric method for the determination of bromide in photographic developer solutions has been described by Evans, Hanson, and Glasoe.⁸ By their procedure a sample of developer solution is treated with excess sulfuric acid, the solution boiled to remove the sulfur dioxide, cooled, and sodium acetate solution added, followed by potentiometric titration with silver nitrate. The proper volume of silver nitrate is determined by use of a curve plotted from the titration data. In the case of certain high solvent developers, such as *D-76*, the authors recommend a preliminary boiling of the solution in order to reduce any silver held in solution. It is stated that in the determination of bromide in aged developer solutions one gram of potassium bromide per liter can be determined with an accuracy of 2 per cent.

In the present work, completed over 3 years ago and given mention in this JOURNAL,⁹ the simple scheme of analysis has been adopted whereby a potentiometric titration is carried out on a sample of developer solution to which a definite excess of acid is added without boiling off the sulfur dioxide or adding acetate solution. As explained later, titrations can be carried to a definite potential thus avoiding the use of a titration curve. Since the error at a given bromide concentration depends upon the ratio of the concentration of the chloride to that of the bromide, and is affected by the presence of nonhalide salts and developer solution constituents, a somewhat detailed study of this error was made with the purpose of obtaining a series of percentage correction curves to be applied to such determinations. Using the procedure described, titrations were made in solutions of

the 2 halides alone, and in solutions formed by addition of the 2 halides to certain salts and developer solution constituents as well as in fresh and used developer solutions. The concentration ranges of bromide and chloride included those commonly present in the analysis of typical developer solutions.

TITRATION OF THE HALIDE MIXTURES

Solutions Used.—The chloride and bromide solutions were prepared from the potassium salts. Mixtures of these solutions were used alone and with addition of potassium alum, sodium sulfite, hydroquinone, metol, and powdered gelatin. Solutions of the chloride and bromide were also added in different proportions to the *D-72* and the used developer solutions described below.

The *D-72* developer solution was halide free and contained in each liter 0.6 gram of metol, 2.5 grams of hydroquinone, 8.3 grams of sodium sulfite, and 14 grams of sodium carbonate. To certain portions of this solution powdered gelatin was added. Through other portions air was passed for 4 hr with and without addition of gelatin.

The used developer solution was furnished by the Hollywood laboratory of Paramount Pictures, Inc. This solution contained in each liter 2.40 grams of hydroquinone, 2.38 grams of metol, 3.50 grams of potassium bromide, 50.3 grams of sodium sulfite, as well as sodium sulfate and products of the oxidation of the hydroquinone and metol. The concentration ratio of chloride to bromide was 0.11 and the *pH* of the solution was about 10.00.

Apparatus.—The titration apparatus consisted of a titration beaker, stirrer, and 2 silver electrodes prepared by electrolytic deposition of silver on platinum wires from a cyanide solution. One of the silver electrodes dipped into the solution being titrated and the other was sealed into the tip of the buret containing the silver nitrate reagent as described by Willard and Boldyreff.³

The potential readings were made by use of a Leeds and Northrup student-type potentiometer.

Potentiometric Titration Procedures.—The silver nitrate solution was standardized with potassium chloride by potentiometric titration. In this titration and in that of all the halide mixtures the solutions were made up to a volume of 100 ml containing an excess of 2 ml of 6*N* sulfuric acid and all the concentrations stated are for this volume. When sulfites or carbonates were present, acid was

added slowly with stirring until the solution was just acid after which 2 ml more were added.

Potentiometer readings were taken at each milliliter addition of silver nitrate until a point about 0.5 ml from the inflection point was reached, after which readings were taken each 0.1 ml until the inflection point was passed.

At a given concentration of acid the solutions containing the same concentrations of halides will always have the same inflection point potential. Raising the acid concentration will cause this potential to be slightly lower. In routine analyses of developer solutions in which the acid concentration is always the same and the halide concentrations do not have a too wide variation, it is quite satisfactory to carry the titration to a definite end point potential.

PRESENTATION AND DISCUSSION OF RESULTS

Table 1 shows the effects of different salts, gelatin, and developer solution constituents on the bromide titration error in a bromide-chloride mixture in which the total halide concentration was 0.0330M

TABLE 1

Effect of Salts, Developer Solution Constituents, and Gelatin on the Bromide Error in a Bromide-Chloride Mixture

Approximately 3.3 milliequivalents of potassium halides in 100 ml of solution acidified with 6N H₂SO₄; concentration ratio Cl/Br—0.76; temperature 26 C.

100 MI Solution of the Halides Containing the Constituents Listed Below

	Per Cent Error in Bromide		Per Cent Error in the Total Halide	
	.01, .05, and .10 gm gelatin		.01, .05, and .10 gm gelatin	
Halides alone	4.0	6.0	0.3	0.7
5 gm potassium alum	2.1	5.8	0.1	0.6
2 and 4 gm sodium sulfite	2.1	5.8	0.4	0.6
1, 2, and 4 gm sodium sulfite and 5 gm potassium alum	1.8	5.8	0.4	0.6
0.1 and 0.15 gm hydroquinone	3.4	5.8	0.4	0.6
0.1 gm hydroquinone and 5 gm potassium alum	2.0		0.2	
0.1 gm hydroquinone and 2.5 gm sodium sulfite	2.0	6.0	0.4	0.6
0.1 gm metol	2.0	5.8	0.3	0.6
0.1 gm metol and 5 gm alum	1.8		0.4	
0.1 gm metol, 2.5 gm Na ₂ SO ₃	1.8	6.1	0.3	0.6
50 ml D-72 developer sol.	2.0		0.3	
50 ml D-72, partially oxidized	2.1	5.9	0.3	0.6

and the ratio of concentration of chloride to bromide was 0.760. It will be noted that the per cent error in the bromide end point when no nonhalide salts are present is about double that when alum is added; and that when solutions of sodium sulfite, metol, and the D-72 developer are used, the errors are practically the same as in the case of alum. Hydroquinone has an error somewhat greater than metol, but this effect is overcome when sodium sulfite is also present. It will be noted that the gelatin error is large even when a high concentration

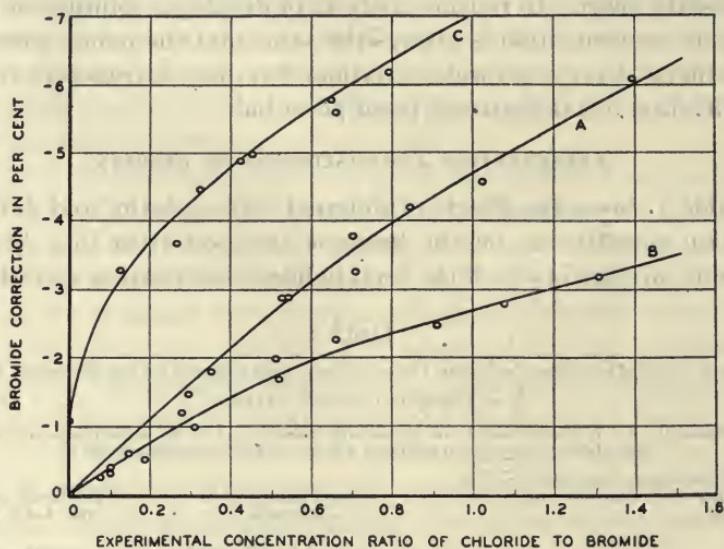


FIG. 1. Bromide corrections in titration of bromide chloride mixtures—0.009–0.02 N in bromide, and 0.0–0.02 N in chloride. A—Halides alone; B—Halides plus alum or in used developer solution; C—Halides in aerated D-72 developer solution containing gelatin.

of electrolyte is present and that for the different amounts of gelatin added the error is practically constant. Of considerable significance is the fact that the gelatin error in the used developer solution evidently was practically negligible.

Table 2 and the curves in Fig. 1 show the bromide corrections for different chloride to bromide concentration ratios in solutions approximately 0.009–0.02M in bromide and 0.0–0.02M in chloride containing the halides alone, and the halides plus various salts and developer solution constituents. In the case of the used developer solution the approximate volume of silver nitrate equivalent to the

bromide originally present was determined by adding further amounts of bromide and chloride, plotting the experimental concentration ratios of chloride to bromide against the volumes of silver nitrate required to reach the bromide inflection point, and extrapolating the

TABLE 2
Bromide Correction in Bromide-Chloride Mixtures

Nature of Solution	Ml of AgNO ₃ to Reach Inflection Points		Experimental Ratio of Chloride to Bromide	Bromide Correction in Per Cent
	Bromide	Chloride		
Halides alone titrated with 0.0990N AgNO ₃	19.27	22.08	0.15	-0.6
	19.50	26.40	0.35	-1.8
	19.72	29.38	0.49	-2.9
	19.90	33.75	0.70	-3.8
	20.00	36.73	0.84	-4.2
	20.07	41.13	1.05	-4.6
	9.32	22.24	1.39	-6.1
	9.99	12.90	0.29	-1.5
	10.14	15.50	0.53	-2.9
	10.18	17.42	0.71	-3.3
Halides plus 5 gm of alum titrated with 0.0990N AgNO ₃	19.26	22.22	0.15	-0.6
	19.36	26.61	0.38	-1.0
	19.45	29.60	0.52	-1.5
	19.55	33.81	0.73	-2.0
	19.65	36.79	0.87	-2.5
	19.70	40.84	1.07	-2.8
	9.08	22.30	1.46	-3.5
Halides added to 50 ml of Paramount used developer solution. Titrated with 0.0979N AgNO ₃	14.94	14.94	0.00	-0.0
	23.83	25.40	0.07	-0.25
	14.98	16.55	0.10	-0.3
	15.13	19.18	0.27	-1.2
	15.26	22.98	0.51	-2.0
	15.30	25.45	0.66	-2.3
	15.33	29.27	0.91	-2.5
	15.38	31.85	1.07	-2.8
	15.44	35.64	1.31	-3.2
Halides and gelatin added to 50 ml of D-72 developer solution oxidized 4 hr by air. Titrated with 0.0988N AgNO ₃	16.94	16.94	0.00	-1.1
	17.33	19.46	0.12	-3.3
	17.55	23.17	0.32	-4.5
	17.65	25.66	0.45	-5.0
	17.75	29.45	0.66	-5.6
	17.86	31.98	0.79	-6.2
	18.05	35.77	0.98	-7.2
	25.89	32.61	0.26	-3.7
	10.71	15.22	0.42	-4.9
	21.43	35.37	0.65	-5.8

curve thus obtained to zero concentration ratio of chloride to bromide.

The results show that in the halide mixtures containing no added salt or other constituent the error varies from 0.6–6.1 per cent compared to 0.6–3.5 per cent for the mixtures in solutions of alum, or developer solution constituents when all are present together. When gelatin is present, the error is increased in all cases and varies from 1.1–7.2 per cent.

Evans, Hanson, and Glasoe⁸ have stated that the per cent error in bromide tolerable before there is a noticeable change in density in a photographic film may be 4–5 per cent in negative developers and as high as 10 per cent in a positive developer. The results in Tables 1 and 2 show that the errors in the titrations made lie well within those limits when one follows the procedure described. In control analyses the percentage error of the titrations is not as important as their reproducibility in solutions of the same type, since the purpose of the control is to correlate analytical results with desired photographic effects. The experience of the Paramount Laboratories, where essentially the same procedure has been used during the past 3 years, shows that in the routine analyses of their positive, negative, and sound track developers all the solutions can be titrated to the same endpoint potential, without the use of a titration curve and still have the deviations lie safely within the tolerance required. Ordinarily an analysis can be made by a routine operator in about 10 min. If one employs the recently developed Beckman automatic titration appara-

TABLE 3

Determination of Bromide in Positive, Negative, and Sound Track Negative Developers. (All Concentrations Are in Grams Per Liter)

	Developer Solutions		
	Positive	Negative	Sound Track Negative
Hydroquinone concentration	4.00	0.50	0.25
Metol concentration	1.75	1.00	1.72
Potassium bromide conc.	3.65	0.40	0.16
Sodium Sulfite conc.	47.0	50.0	55.0
Sodium Carbonate conc.	7.00	...	...
Sodium sulfate conc.	29.0	...	...
Borax conc.	...	6.5	2.4
Citric acid conc.	...	0.34	0.52
Conc. ratio Cl/Br	0.10	0.52	1.2
pH	10.00	9.00	8.80
Estimated error, per cent	0.5	2.0	3.0
Average deviation, per cent	0.5	1–2	2–3

tus, this time can be shortened still further, since the titration operation and registering of results are performed automatically.

Table 3 shows recent data obtained in the analysis of certain typical used positive, negative, and sound track negative developer solutions. All titrations were carried to a predetermined end-point potential. In one series of runs a buret electrode was used and in another series a calomel electrode such as that described in the next section was employed. Either electrode is satisfactory but the buret electrode is more conveniently handled by the routine analyst. The estimated

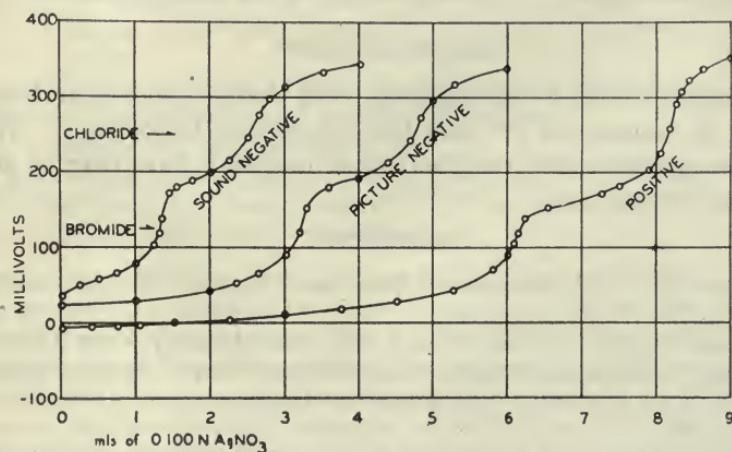


FIG. 2. Titration curves for samples of continuously replenished developers. Abscissae of sound negative and picture negative curves are plotted full scale, while those of positive film curve are three-fourths scale.

per cent errors are taken from the curve in Fig. 1. In none of the solutions was there found difficulty owing to dissolved silver.

ROUTINE PROCEDURE AT THE PARAMOUNT LABORATORY

The following procedure is used in the Paramount Laboratory in its routine bromide titration of a positive developer solution: 25.0 ml of developer solution are run into a 500-ml beaker, 0.5 ml of brom cresol green indicator added, followed by 75 ml of distilled water. Concentrated sulfuric acid is added drop by drop until the solution turns yellow. Then 0.5 ml of acid is added in excess, and finally 100 ml more of distilled water. A silver electrode and a saturated calomel electrode provided with a ground glass joint designed to prevent chloride diffusion are then introduced into the solution, the proper

potentiometer adjustments made, the stirrer started, and silver nitrate solution added dropwise at a rapid rate until the potentiometer reads about 70 mv. The silver nitrate is then added slowly, allowing time for each addition to reach equilibrium. The end point is taken at 120 mv.

The procedure for negative and sound track negative developer solutions is the same as that described above except that 100-ml samples are taken.

Fig. 2 shows a set of typical titration curves obtained by use of the foregoing procedures. The temperature of the solutions was 67 F.

ACKNOWLEDGMENT

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BOOK REVIEW

The Measurement of Colour. By W. D. WRIGHT. Adam Hilger, Ltd. (London), 1944, 232 + vii pp.; 65 diagrams and illust., 6 figs. in color.

This is a remarkably well-written book, and one which will fill a long-felt need. The title of the book gives no true indication of the breadth and depth of its coverage. The chapter headings give a somewhat better indication. They are:

- I. Radiation in the Visible Spectrum: Its Emission, Absorption and Reflection.
- II. Radiation in the Visible Spectrum: Its Reception by the Eye.
- III. The Trichromatic System of Colour Measurement.
- IV. Colorimeters: Their Design and Use.
- V. Spectrophotometry Applied to the Measurement of Colour.
- VI. The Colour Atlas as a Sub-standard of Colour Measurement.
- VII. Practical Applications of Colorimetry.

Supplementing these there are 3 appendices with 7 condensed tables.

The last chapter is of particular value. Among its section headings are: The Colouring Power of Chemicals and Their Mixture, Lighting, The Paint Industry, Signal Glasses, and Colour Reproduction. The last mentioned section, which has particular application to color photography, is all too short; but it contains references to other more extensive articles. In particular an article by the same author in the *Photographic Journal* in 1940 gives a much more extensive treatment of color photography.

As the use of color in motion pictures increases, and more particularly as some of the newer processes are offered to and used by the industry, a great many engineers, especially sound recording engineers, are going to be interested in the harnessing and control of color reproduction processes. These engineers are not going to be measuring colors (except perhaps occasionally) but they will be, so to speak, dwelling in color space and some of them will want to "know their way around." Dr. Wright's book can be recommended as a most thorough guide book.

The physics of color presents peculiar difficulties, especially to the engineering mind. This is largely because color does not properly belong in the domain of physics, but rather that of psychophysics. Engineers deal so exclusively with the external world that the very word psychophysics is scarcely in the engineering vocabulary. The motion picture sound engineer deals with psychophysical relations when musical sensations are treated in terms of vibrations, amplitudes, etc. But in the science of music the relationship of pitch, harmony, loudness, etc., to frequencies, ratios, and amplitudes of aerial vibrations is so simple and so closely alike for all individuals that the science of music moves effortlessly over into the domain of physics. In fact, the distinction between the two aspects seems rather labored.

Not so in the case of color. There are no colors in the external world, but only electromagnetic vibrations, variations in reflection factors, *etc.* The sensation of color is manufactured by the human eye and its attendant nervous mechanism. The sense of color can be most closely compared with the sense of absolute pitch. Very few people possess the latter, and very few people fail to possess the former. The way in which, by the device of a standard observer, this phenomenon can be treated as if it were a branch of physics is not without its pitfalls.

There has been for some time a great need for a book on the science of color which would have the following qualities:

- (1) Never to ignore the experimental background against which the standard observer was erected, or to ignore the standardizing limitations to which he must submit;
- (2) Present the necessary mathematics in the simplest possible terms, recognizing but not pursuing mathematical complexities;
- (3) Describe and evaluate the various types of color measuring devices, their capabilities and limitations;
- (4) Describe the applications of the methods to various industries with due regard to tolerances and the incidence of unusual psychological conditions.

"The Measurement of Colour" is just such a book. A man better qualified than Dr. Wright to write it could scarcely be found. His determination of the color mixture curves for a group of observers, published in 1929, was one of the chief courses of data for the specification of the standard observer. He is one of the outstanding workers in the science of color. His presentation of the entire subject is sound, thorough, and clear, without either skipping over the difficulties or delving into them abstrusely.

Criticism of such a book can only be of a minor nature. One could wish it had more brilliantly conceived and executed colored illustrations similar to some of those which appeared in *Life* some months ago. Probably wartime limitations on color printing in England have prevented that.

A minor criticism of the text can be made in saying that Dr. Wright in sketching the evolution of the trichromatic system has not properly accredited the report, published in 1922, of the Colorimetry Committee of the Optical Society of America headed by Dr. L. T. Troland, which first surveyed the field broadly and foreshadowed the specification of a standard observer. However, he has properly accredited Dr. H. E. Ives, now of the Bell Telephone Laboratories, for his part in setting in motion the modern phase of development in the Science of Color with his 1915 paper in the *Journal of the Franklin Institute*, an item which is frequently overlooked in this country.

The book is obtainable in this country from the Jarrell-Ash Company, 165 Newbury Street, Boston, Massachusetts.

J. A. BALL
May 16, 1945

SOCIETY ANNOUNCEMENTS

ATLANTIC COAST SECTION MEETING

The development of Ansco color motion picture film was discussed by John L. Forrest of the Research Department, Ansco Division, General Aniline and Film Corporation, Binghamton, N. Y., before the meeting of the Atlantic Coast Section of the Society in New York on April 18. Mr. Forrest, who has been engaged for a number of years on problems relating to Ansco color film, discussed the general principles involved in the process, showing how the colors are photographed in different layers in the film and dyes are produced in these layers in the subsequent development.

Mr. Forrest described in some detail a 16-mm color developing machine, illustrating his talk with color slides of the equipment. At the conclusion of his paper, he showed samples of 16-mm Ansco color film representing typical amateur motion picture photography.

Over 200 members and guests of the Section were present in the *Salle Moderne* of the Hotel Pennsylvania. The program opened with a showing of the film, *Blood Bank at Natura*.

EMPLOYMENT SERVICE POSITIONS OPEN

Young man with several years' experience in Motion Picture Camera and Projector design. Must have mechanical background with a knowledge of motion picture industry requirements. Write or telephone for interview. Akeley Camera, Inc., 175 Varick St., New York 14, N. Y. WALKER 5-7954.

Optical engineer's assistant. Acquainted with optical laboratory routine, ray tracing and similar problems in related scientific fields. Reply to Optical Engineering Department, DeVry Corporation, 1111 Armitage Ave., Chicago 14, Ill.

Position open for man or woman with experience in optical instrument design. Position also open for man or woman with experience in lens design or computing. Write for interview. Binswanger and Company, Optics Division, 645 Union Ave., Memphis, Tenn.

Physicist with special training in optics for research on utilization of carbon arcs particularly in projection systems. Apply to Research Laboratory, National Carbon Co., Inc., P. O. Box 6087, Cleveland 1, Ohio.

POSITION WANTED

Engineer desires position with manufacturer or theater circuit supervising construction, maintenance, or operation. Sixteen years' experience. For details write P. O. Box 710, Chicago, Ill.

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(Correct to May 31, 1945)

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Room 813
350 Madison Ave.
New York 17, N. Y.

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NONTHEATRICAL EQUIPMENT.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of 16-mm motion picture projectors, splicing machines, screen dimensions and placement, loudspeaker output and placement, preview or theater arrangements, and the like, which will improve the reproduced sound and picture quality of 16-mm prints.

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(Under Organization)

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J. G. FRAYNE, *Chairman*
6601 Romaine St.
Hollywood 38, Calif.

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STANDARDS.—To constantly survey all engineering phases of motion picture production, distribution, and exhibition to make recommendations and prepare specifications that may become proposals for SMPE Recommended Practices and/or American Standards. This Committee should carefully follow the work of all other committees on engineering and may request any committee to investigate and prepare a report on the phase of motion picture engineering to which it is assigned.

F. T. BOWDITCH, *Chairman*.

Box 6087

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1016 N. Sycamore St.
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(Under Organization)

TEST FILM QUALITY.—To supervise, inspect, and approve all print quality control of sound and picture test films prepared by any committee on engineering before the prints are released by the Society for general practical use.

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* Advisory Member.

June, 1945

COMMITTEES OF THE SOCIETY

Subcommittee on Film Projection Practice.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture projection equipment, projection rooms, film storage facilities, stage arrangement, screen dimensions and placement, and maintenance of loudspeakers to improve the quality of reproduced sound and the quality of the projected picture in the theater.

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Subcommittee on Television Projection Practice.—To make recommendations and prepare specifications for the construction, installation, operation, maintenance, and servicing of equipment for projecting television pictures in the motion picture theater, as well as projection room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in high-quality theater television presentation.

P. J. LARSEN, *Chairman*
1401 Sheridan St., N. W.
Washington 11, D. C.

F. E. CAHILL, JR., *Vice-Chairman*
321 West 44th St.
New York 18, N. Y.

JAMES FRANK, JR., *Secretary*
356 West 44th St.
New York 18, N. Y.

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Nela Park
Cleveland 12, Ohio

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COMMITTEES OF THE SOCIETY

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Subcommittee on Theater Engineering, Construction, and Operation.—To make recommendations and prepare specifications on engineering methods and equipment of motion picture theaters in relation to their contribution to the physical comfort and safety of patrons, so far as can be enhanced by correct theater design, construction, and operation of equipment.

HENRY ANDERSON, *Chairman*
1501 Broadway
New York 18, N. Y.

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American Standards Association:	
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<i>Sectional Committee on Motion Pictures, Z22 (Chairman being elected and committee organized.)</i>	
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Society of Motion Picture Engineers

HOTEL PENNSYLVANIA
NEW YORK, N. Y.

APPLICATION FOR MEMBERSHIP

APPLICANT'S RECORD

Name..... Age.....

Mailing Address.....

Present Occupation.....

Employer.....

A complete account of the applicant's qualifications and accomplishments is required before an application may be submitted to the Board of Governors. The applicant should describe any inventions and improvements he has made in the art, as these are considered of more importance than a mere record of experience or the names of positions the applicant has filled.

Education.....
.....

Record of Accomplishments.....
.....

Motion Picture Experience.....
.....

Grade Applied For.....
(Active, Associate, or Student)

REFERENCES

1. 3.

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2. 4.

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The undersigned certifies that the above statements are correct, and agrees, if elected to membership, that he will be governed by the Society's Constitution and By-Laws so long as his connection with the Society continues.

Date..... 19... Signed.....

(Use a separate sheet of paper for complete record of accomplishments)

